High Performance Building **Guidelines**

City of New York
Department of Design
and Construction

April, 1999

Executive Acknowledgements

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Commissioner's Foreword

To the Reader:

As we enter the new century, the City of New York is in a unique position to improve the overall quality and performance of public buildings that are constructed and renovated by the Department of Design and Construction (DDC). We can do that by increasing our reliance on energy and environmentally efficient construction technologies and practices, by taking advantage of the strides that have been made over the past few years in the field of ‘green buildings.‘

Key to the success of that effort is our ability to make responsible investments to improve the environment without constraining economic activity. We are now in a position to do that, and, under the leadership of Mayor Rudolph W. Giuliani, are moving ahead to make New York City an environmental prototype for the 21st Century.

These *Guidelines* outline strategies and techniques that can move us toward that goal. They set out a range of ’best practices‘ for planning, designing, constructing and operating healthier, more energy – and resource – efficient facilities. Such high performance buildings can earn long term life cycle savings for New York City, and may also help stimulate the markets for environmentally efficient technologies. By integrating high performance features into its capital projects, DDC adds value to the City‘s capital assets while helping to protect the environment and support local economic activity.

Luis M. Tormenta, P.E.
Commissioner
April, 1999

Design Trust for Public Space Preface

In 1998, the Design Trust for Public Space offered to sponsor the Department of Design and Construction's production of *High Performance Building Guidelines*. A private, not-for-profit organization dedicated to improving the design and understanding of public space in New York City, the Trust funds and manages projects that deploy creative design resources to affect significant issues of urban policy or the public built environment. This project was selected because it acknowledges and strengthens the essential role of public sector design in environmental stewardship. By educating both public sector capital designers and planners in the "why" and "how" of sustainable design, the research and resulting guidelines will help transform DDC's building practices. The Trust is pleased that this initiative has been able to build upon DDC's previous efforts in creating environmentally sound design, and believes that the adoption of *High Performance Building Guidelines* will help situate New York City at the forefront of large municipalities committed to environmentally responsible building.

We are confident that the results of this collaborative effort will bear out the Design Trust's belief that New York City's public environment is indeed well served when public and private practitioners come together to focus on design. Throughout the project, DDC and the Design Trust worked as partners, and were supported by an interagency Steering Committee, including members from the Office of Management and Budget, Mayor's Office of Construction, the Office of Energy Conservation, and the New York State Energy Research and Development Authority. This collaboration jointly developed the framework of the study, staffed it with appropriate professional expertise, recruited in-house and interagency contributing authors, monitored its progress, and secured foundation project funding through the Trust.

The Design Trust wishes to acknowledge the critical support of the New York State Energy Research and Development Authority, who underwrote the involvement of environmental design experts Steven Winter Associates, who provided critical technical assistance and information. We are particularly grateful to the Mayor's Office of Grants Administration for their invaluable guidance with respect to foundation project support. We are deeply grateful to the Robert Sterling Clark Foundation, the Energy Foundation, and the New York State Council on the Arts, for their financial support of this project.

Andrea Woodner
Director
April, 1999

Preface

Background Through a recent series of initiatives, New York City is laying the groundwork to introduce significantly improved energy- and resource-efficient practices into its public facility construction programs. Policymakers are seeking to capitalize on the economic and environmental benefits of 'green' buildings. NYC recognizes that improving the environmental performance of its facilities will add value to its large portfolio of capital assets, and at the same time, yield important 'quality of life' benefits for New Yorkers.

Initial plans for integrating sustainable practices into municipal design and construction were developed by a core steering committee of the NYC Green Buildings Task Force, an interagency collaboration organized by the Mayor's Office of Construction, with the Office of Management and Budget and the Department of Design and Construction. The Task Force recently completed its *Environmentally Responsible Building Guidelines Project*, which examines the feasibility of rolling out energy – and resource – efficient practices across the NYC capital program. The project was carried out by an interdisciplinary academic team from the University Consortium,[1] an association of seven NYC technical universities, together with consulting professionals and the City's Task Force.[2]

The 'Environmentally Responsible' Building Guidelines Project The project's *research component* inventoried green building guidelines, design standards and case studies of other government entities to determine their relevancy to NYC's public contracting environment. *Dedicated workshops* convened various construction industry representatives to examine constraints and opportunities presented by the use of green practices. A *financial analysis* examined the costs and benefits of applying environmentally sensitive guidelines across the City's capital construction program, looking at first cost, operational, and life cycle cost differentials. This project's recommendations have informed the development of these *Guidelines*. An executive summary of the project appears in the Appendix.

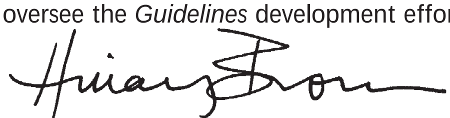
Department of Design and Construction and Other Agency Initiatives The recently centralized construction agency handling infrastructure and building projects, the Department of Design and Construction (DDC), has developed a dedicated "High Performance Building" program. Through demonstration projects (including both renovation and new construction), policy development, outreach, and education, DDC has begun to mainstream selected green building objectives – energy efficiency, pollution and waste abatement, indoor air quality, resource conservation, and others – into its clients' facilities. Through the participation of oversight agencies, other project initiatives have been undertaken by the School Construction Authority, Health and Hospitals Corporation, and Economic Development Corporation.

Partnerships behind the *High Performance Building Guidelines* Project This project builds on the work of the above-mentioned *Environmentally Responsible Building Guidelines Project*, and on recent DDC experience in undertaking several high performance demonstration projects. Like the previous study, the *High Performance Building Guidelines* are the product of a collaborative process and resulted from a wide range of contributions.

In the preparation of these *Guidelines*, significant input was sought from the very technical and project management personnel who will implement them on future projects. Under the guidance of the project team, more than twenty staff members of DDC researched, wrote and illustrated much of the material. Significant authorship contributions were also forthcoming from several interagency participants representing the Departments of Parks and Recreation, Environmental Protection, and the Office of Management and Budget. Also participating were representatives of the Mayor's Office of Construction and the Office of Energy Conservation.

A technical assistance grant from New York State Energy, Research and Development Authority (NYSERDA) supported the participation of the firm Steven Winter Associates in much of the technical research and facilitation of the chapter workshops. In-kind staff resources were also contributed by the Natural Resources Defense Council, INFORM, and Markets for Recycled Products.

Above all, the Design Trust for Public Space[3], a non-profit organization dedicated to improving the design, creation and understanding of public space throughout New York City, provided funding and management support for the project. The Design Trust provided underwriting for the participation of two Design Trust Fellows who helped DDC oversee the *Guidelines* development efforts and provided administrative support for the project.



Hillary Brown, AIA
Assistant Commissioner
Office of Sustainable Design and Construction

1. Participating schools included (1) the Graduate School of Architecture, Planning, & Preservation, and the Earth Engineering Center at Columbia University, (2) City University - Hunter College, Center for Applied Studies of the Environment, (3) City College of NY School of Architecture, and (4) Polytechnic University. See Acknowledgments section for participants.
2. Other participating agencies include the Office of Energy Conservation, Department of Citywide Administrative Services, the School Construction Authority, and the Board of Education. The project received a grant from the New York State Energy, Research and Development Authority (NYSERDA). See Acknowledgments section for participants.
3. The Design Trust: www.designtrust.org

Executive Summary

The central mission of the New York City Department of Design and Construction (DDC) is to deliver the City's construction projects in a safe, expeditious, cost-effective manner, while maintaining the highest standards of architectural, engineering, and construction quality. These *Guidelines* identify opportunities to improve DDC's business practices which will in turn yield the highest overall return for the City's capital investments.

High performance buildings maximize operational energy savings; improve comfort, health, and safety of occupants and visitors; and limit detrimental effects on the environment. The *Guidelines* provide instruction in the new methodologies that form the underpinnings of high performance buildings. They further indicate how these practices may be accommodated within existing frameworks of capital project administration and facility management.

Working within existing capital and operational practices, these *Guidelines* require careful judgment at all stages in project development to ensure the fiscal integrity of the capital project. The *Guidelines* encourage the formulation of responsible budgets at the planning stage. Further, they mandate that the design team identifies any high performance cost premiums (together with cost savings) and justifies them to the City's satisfaction.

DDC's *Guidelines* contribute to a growing body of literature nationwide that seeks to promote environmentally sound building construction. In preparing these *Guidelines*, DDC sought significant input from the very technical personnel who will implement them on future projects. More than 20 staff members researched and wrote and illustrated much of the material under the supervising expertise of outside consultants. The effort also involved significant contributions from other city agencies.

High Performance Building Guidelines Goals

- ☆ Raise expectations for the facility's performance among the various participants.
- ☆ Ensure that capital budgeting design and construction practices result in investments that make economic and environmental sense.
- ☆ Mainstream these improved practices through 1) comprehensive pilot high performance building efforts; and 2) incremental use of individual high performance strategies on projects of limited scope.
- ☆ Create partnerships in the design and construction process around environmental and economic performance goals.
- ☆ Save taxpayers money through reduced energy and material expenditures, waste disposal costs, and utility bills.
- ☆ Improve the comfort, health and well-being of building occupants and public visitors.
- ☆ Design buildings with improved performance which can be operated and maintained within the limits of existing resources.
- ☆ Stimulate markets for sustainable technologies and products.

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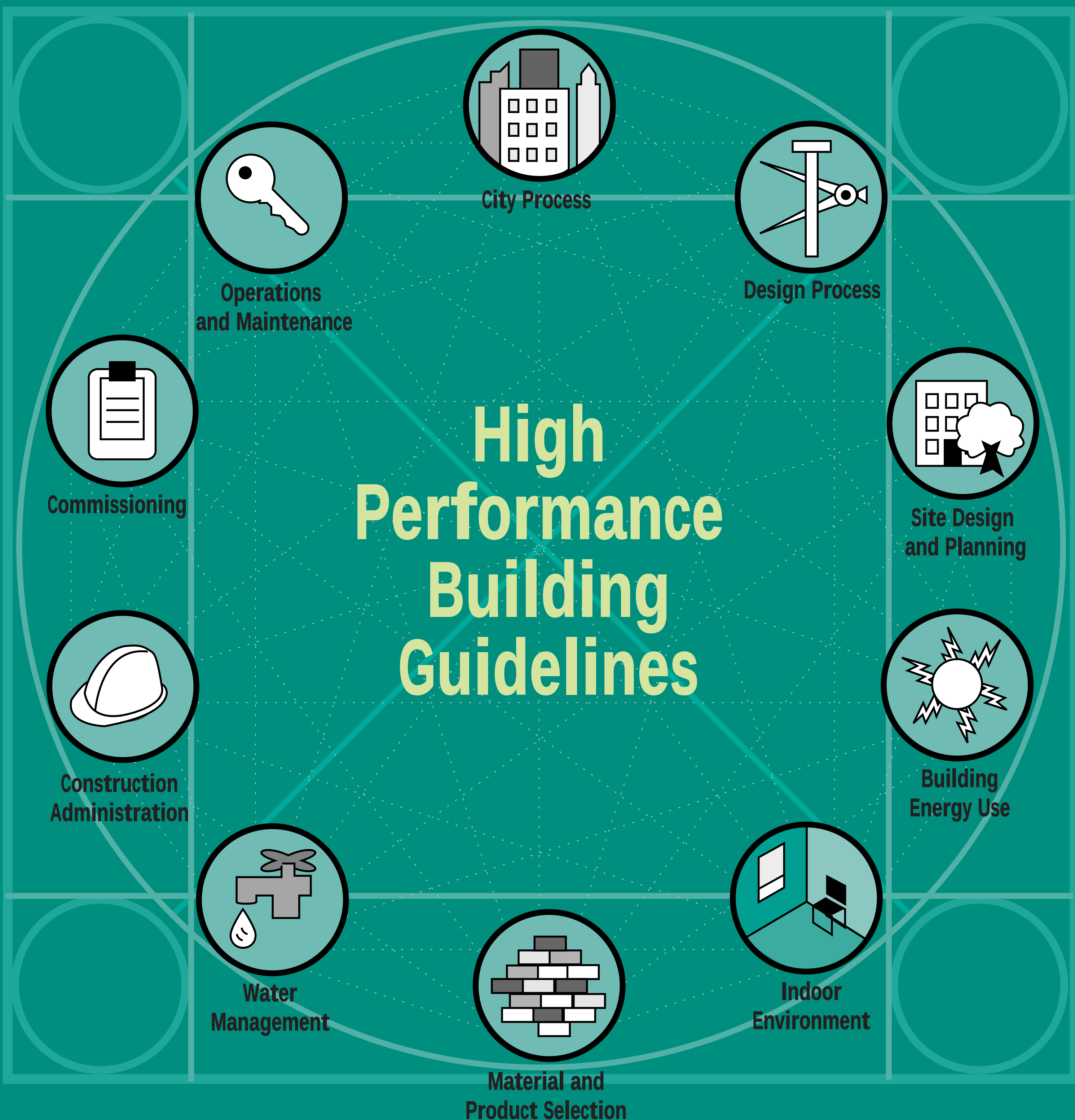

Based on a design by Carol Latman

Part One: Overview

On any given capital project, dozens of players from both the public and private sectors participate in planning, programming, funding, design, construction, and operation of a municipal facility. The *High Performance Building Guidelines* help each participant better understand their role in producing improved, more efficient buildings with reduced environmental impacts.

These *Guidelines* will take each participant through the new practices that must be adopted in order to realize these goals and achieve the higher degree of collaboration necessary to reach the targeted performance objectives. As a tool, the *Guidelines* are meant to both instruct and facilitate input from public agency executives and line staff; oversight agencies and elected officials; architects and engineers; subcontractors, journeymen, and building custodians; and the visiting public.

Participants should identify the *Guidelines* section(s) most applicable to their project roles suggested by the following chart.

All participants are strongly urged to read Parts I and II in their entirety.

Participants

All participants are strongly urged to read Parts I and II in their entirety.

Key Chapters

Participants	City Process	Design Process	Site Design and Planning	Building Energy Use	Indoor Environment	Material and Product Selection	Water Management	Construction Administration	Commissioning	Operations and Maintenance
Building Owners										
Sponsoring Agencies Capital planning and budgeting, facility management and operation	●	●	○	○	○	○	○	○	●	●
DDC Program Managers Project administration	●	●	●	●	●	●	●	●	●	●
DDC Architecture & Engineering Technical group that develops the Specific Requirements and reviews the documents	●	●	●	●	●	●	●	●	○	●
Regulatory and Other Agencies										
Building Department, City Planning, Department of Environmental Protection, Department of Transportation Review and approve plans and specifications	●	○	●	●	●	●	●	●	○	○
Department of Sanitation, DCAS/Office of Energy Conservation Perform facility-specific services during operations; provides energy services	○	○	○	●	●	●	○	○	●	●
Funding Entities										
OMB Task Force and Capital and Expense Budget Review Approve budget requests; analyze program requirements	●	●	○	○	○	○	○	○	●	●
Elected Officials, City Council, Private Organizations, Other Funding Groups Develops project description	●	○	○	○	○	○	○	○	●	●
Building Industry										
Architects Overall project design and coordination; production of drawings and specifications	○	●	●	●	●	●	●	●	●	●
Landscape Architects, Horticulturalists, Civil Engineers Design of site plan, roads, drainage, plantings, site furnishings	○	●	●	○	○	○	●	●	○	●
Mechanical, Electrical, and Structural Engineers HVAC and electrical systems, plumbing, utility connections, structural design	○	●	○	●	●	○	●	●	●	●
Construction Managers, Cost Estimators, Commissioning Agents Review, estimate and administer construction; commission the building	○	●	●	●	●	●	●	●	●	●
Contractors, Subcontractors, Building and Trade Associations, Waste Handlers, etc. Bid and construct the project; commission the building	○	○	○	●	●	●	●	●	●	●
Other End-Users										
Public Clientele, City Taxpayers Building users and visitors	●	●	●	●	●	●	●	●	●	●
Other Readers										
Other Municipalities Progressing other sustainable programs/initiatives	●	●	●	●	●	●	●	●	●	●
Interested Real Estate Professionals Progressing other sustainable programs/initiatives	○	●	●	●	●	●	●	●	●	●

Guidelines Format

Building industry professionals will notice that the *Guidelines* is not organized according to traditional technical areas. To introduce new practices that require a higher level of interdisciplinary coordination, this publication has been formulated around high performance objectives that cut across multiple disciplines and technical areas of expertise.

Each of the chapters in Parts II and III follow a common format designed to lead the project team through the basics of green building design, construction, and operation. Beginning with the general issues or principles involved and progressing to specific tangible activities, each chapter contains a series of high performance **Objectives**, a summary explanation of **Benefits** that pertain to each objective, and a series of **Technical Strategies** to be used in achieving that objective.

- **Objectives**
  The objectives are summary statements of the key high performance principles or practices that are becoming more widespread throughout the industry. Supporting examples and graphics further clarify or expand on these objectives.
- **Benefits**
  Each objective has a number of benefits or advantages that may be captured using the technical strategies that follow. Benefits may be direct or indirect.
- **Technical Strategies**
  A series of recommended design approaches describe the means required to capture the benefits. Strategies may include design methodologies, use of new technologies, or administrative practices.
- **Example**

Benefits

O_M
Reduced use lowers municipal costs for water treatment

C_M
Widespread conservation reduces demand and can avoid future waste water treatment facilities construction, along with associated capital costs.

Minimize the Use of Domestic Water

Proper selection of plumbing fixtures, equipment, and fittings can minimize end use of domestic water while conserving water quality and availability.

Technical Strategies

❑ **Fixture and fitting selection.** Select plumbing fixtures and fittings that evince state-of-the-art capabilities in terms of water conservation. Seek improved performance by specifying low water usage water closets, urinals, showers, and lavatories–especially those that perform above the standards already mandated by federal, state and local laws. Consider the use of:

- Pressure-assist toilets
- Composting toilets
- Waterless urinals (in high use areas)
- Automatic shut-off controls on sinks, toilets, and urinals

❑ **Ozonation.** Consider ozonation in commercial laundering systems, condenser water systems, and other special uses to reduce water usage and secure other benefits.

Water Savings – Toilets and Faucets
New York's Marriot Marquis Hotel replaced 1,800 guest room toilets (operating at approximately five gallons per flush) with 1.6-gallon pressurized-tank toilets, resulting in an 18% reduction in total water use. In addition to typical residential water end uses, the hotel also has extensive restaurant, catering, and recreational facilities, as well as some laundry facilitiesDuring 1994-1997, the New York City Department of Environmental Protection (DEP) sponsored the replacement of 1.33 million toilets citywide. Some show. erheads were replaced and faucet aerators installed as part of the project. An impact evaluation of project results in multi-family buildings found an average reduction in water use of 29%, or 69 gallons per apartment per day.

Ozone Laundry
Ozone laundry systems use ozone (oxygen activated with an electrical charge) in lukewarm water to reduce the need for detergents, bleach, and hot water. Ozone is a short-lived, unstable gas that is created on site with an electrical generator, and immediately begins to convert back to oxygen. In the process, it oxidizes fatty oils and breaks the bond between dirt and clothing. Ozone laundry systems complement traditional laundry equipment in facilities handling large quantities of textiles, such as hospitals, nursing homes, and correctional institutions. Ozone is also an extremely effective biocide. Other benefits include hot water (energy) savings, reduced water and sewer costs, chemical cost reductions, improved sewage quality, and reduced textile degradation.

Water Management

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The reader will also find coverage of **Building Integration** issues (impacts on other building parts) and **Performance Goals**, or technical benchmarks for use in gauging progress on a given project. **Deliverables** are those separate submittals required over and above what is called for in the *Guide for Design Consultants.* Each chapter also contains information on design or construction **Tools**, as well as **References** to other sources of information, building codes and standards, and background research.

Building Integration

Site Design and Planning. There is a relationship between site harvesting of and storage of rainwater and minimizing the facility's domestic water use by utilizing this retained water for non-potable uses.

Building Energy Use. Reduced hot water usage lowers building energy consumption.

PERFORMANCE GOALS

Water Management

LEVEL 1

- ❑ Use plumbing components that are certified to meet ANSI/NSF 61 *(see Tools).*
- ❑ Where appropriate, use harvested or retained water for seasonal irrigation of all plant materials and/or non-potable water uses within the building.

LEVEL 2

- ❑ The facility should maintain water quality that meets EPA's maximum contaminant level goals (MCLGs) *(see Tools).*
- ❑ Integrate zero water use fixtures and graywater systems as appropriate.

Tools

- ➤ ANSI/NSF Standard 61 – *Drinking Water System Components-Health Effects.* Web site: www.nsf.org
- ➤ EPA Code of Federal Regulations, Parts 141-149.
- ➤ New York State Department of Health publishes a listing of certified testing labs.

Deliverables

Preliminary Design. Testing data, to include:

- ❍ ANSI/ASME performance test results for plumbing fixtures.
- ❍ NSF certification and testing data for plumbing components.
- ❍ Quantified potential savings from water management strategies.

Construction.

- ❍ Lab results of water quality testing at the point(s) of incoming service.

Post-Construction.

- ❍ Lab results of water quality testing at taps.

Regulatory Constraints

➠ The NYC Building Code does not specifically address approved materials and methods for the use of graywater. All innovative systems (such as those strategies suggested above) may raise issues of concern with local code authorities. Effective implementation requires working closely with code officials to obtain a variance for using non-potable water as flushwater for water closets and urinals, as well as for other graywater uses. In addition, regulatory approvals are required for the use of vacuum-assist water closet systems.

References

California Department of Water Resources. *Industrial/Commercial Drought: Guidebook for Water Utilities*, State of California, The Resources Agency, 1991.

California Department of Water Resources, *Water Efficiency Guide for Business Managers and Facility Engineers*, State of California, The Resources Agency, 1994.

Dietmann, A.J. and S.J. Hill, "Water and Energy Efficient Clothes Washers," in *Proceedings of Conserve '96*, American Water Works Association, 1996.

Water Management

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• Building Integration
More than ever, buildings perform as a series of interconnected systems. This section refers readers to other chapters when it's necessary to understand related issues.

• Performance Goals
For each chapter or subchapter, performance goals establish building performance targets. Wherever possible, these are expressed against current industry benchmarks, technical standards, or reference standards. The consultant will need to ensure that these are still current. In some cases, performance goals have been offered at two levels: **Level 1** can be practically achieved through a focused design effort. **Level 2** may involve a more concerted effort and additional design or construction costs.

• Deliverables
To improve building performance or establish that the project meets a higher level of performance, the consultant, contractor, or client may need to submit additional documentation or drawings. Some of these deliverables will be in addition to submittals outlined in the *Guide for Design Consultants* or *Client Manual*.

• Tools
The industry is developing useful design aids, many of them computer-based, that enable the team to better visualize or understand a building's performance.

• Regulatory Constraints

• References
Books, manuals, reference standards, articles, other sources of information on the chapter topic.

Use of the Guidelines with Other Documents

The *Guidelines* have been written in such a way as to complement a wide range of existing documents that govern the design, construction, and operation of the NYC capital projects managed by DDC. These include City procedural manuals and contract documents. In addition, the *Guidelines* also reference the large volume of available information on green buildings and green building evaluation and rating systems.

Relationship of the Guidelines to other DDC documents

NYC DDC *Guide for Design Consultants*, the Agreement, and the Specific Requirements

The consultant's contract consists of three documents: the Agreement, the Specific Requirements (SR), and the *Guide for Design Consultants*. Taken together, the Agreement, which the consultant signs, and the SR define the consultant's contractual obligations for the project at hand. The *Guide for Design Consultants* supplements the Agreement and SR.

The *High Performance Building Guidelines* will affect these documents as follows:

> *The Guidelines will be used by the client agency and DDC program and technical staff in writing the SR. The Guidelines will help identify and define additional contract deliverables over and above those called for in the Guide for Design Consultants. These will be called out in the SR.*

NYC DDC Client Manual

The *Client Manual* documents the procedures carried out by DDC in administering capital projects on behalf of its sponsor agencies. The client agencies' roles and responsibilities are described therein.

> *The Guidelines will affect this document by further defining the client agencies' responsibilities prior to project commencement – budgeting, site selection, strategic planning, and programming, as well as additional responsibilities during design procurement, design, and construction. The Guidelines describe additional responsibilities such as commissioning, operations and maintenance procedures.*

Relationship of the Guidelines to existing codes and standards

The establishment of standardized 'whole building' energy and environmental performance goals has proven to be a difficult and complex task for the building industry. This is due in part to the fact that building energy and environmental performance varies significantly based on climate, building type, operational use profiles, and other variables. In addition, technology is rapidly transforming the configuration, composition and use of materials and equipment.

In terms of building energy use today, the governing standard for the performance goals established in these *Guidelines* is the New York State Energy Conservation and Construction Code (NYS Energy Code), last amended for non-residential buildings in 1989. It establishes the minimum building construction and mechanical system efficiencies that must be achieved in order to produce a code-compliant building in New York State today. At present, the NYS Energy Code falls short of current commercial building practice, and is being revised to reflect current technology and practice. Similarly, indoor air quality issues are covered by such standards as ASHRAE 62-1989, a standard long under public review that is now under "continuous maintenance."

Despite these limitations, the performance goals contained in the *Guidelines* are expressed, wherever possible, in terms of meeting or exceeding current industry codes, technical standards, or reference standards.

Relationship of the Guidelines to green building rating systems

At this time, a number of national and international building rating and evaluation systems are being developed to better define the attributes of a green building, and provide a definitive standard for high performance from a 'whole building' perspective. The US Green Building Council[4] has developed the LEED™ Green Building Rating system. The system strikes a balance between effective practices and emerging concepts through its feature-oriented use of energy and environmental principles to earn credits toward certification. The system merits comparison with other emerging international rating systems, such as BREEAM.[5] The reader is encouraged to reference the LEED credits system in relation to the performance goals and technical strategies contained in these *Guidelines*.

4. The US Green Building Council is the only nonprofit consensus coalition of the building industry which promotes the understanding, development, and accelerated implementation of "green building" policies, programs, technologies, standards and design practices.
5. Building Research Establishment Environmental Assessment Method, an industry standard for assessing a building's environmental quality and performance.

Applying the Guidelines to NYC capital projects

New construction vs. renovation

The *Guidelines* define objectives, strategies, benefits, performance goals, etc. that will apply to either *renovation* or *new construction*. In some cases, the performance goals may differ, because in a renovation, the building's site, orientation, massing, structural systems and other attributes already exist. Their performance may be upgraded, but they cannot be radically altered, and therefore performance expectations may be realistically downgraded.

Building renovations and systems upgrades

Client agencies may dramatically improve an existing building's performance if they follow the planning principles contained in the *Guidelines*. One key principle relates to *building integration*, which recognizes that the various architectural, mechanical, and electrical systems are interdependent. Capital planning, therefore, should take into account a long-term view of the whole building. Even with limited capital funding, incrementally improving the building envelope and various building systems in the right order will result in long-term operating and capital savings when the following principles of building integration are applied:

1. Make comprehensive facility investments and perform them in the proper sequence to ensure appropriate load matching.
2. Improve the thermal performance of the building envelope first, while properly sequencing the upgrade(s) of mechanical and electrical systems. Replacement of whole central systems should come last in the order of priority.

For example, building exterior 'weatherization' or stabilization, such as window replacement or improved roofing insulation, reduces heating and cooling loads. High-efficiency lighting upgrades and replacing fans and motors in air-handling systems may further reduce loads. These improvements should *precede* or be *performed simultaneously with* replacement of major HVAC equipment to ensure proper load matching. This sequence avoids wasting money on major HVAC equipment investments that would otherwise become partially redundant based on later load reductions.

New construction

A new facility that's planned with an eye toward sustainability from day one represents an unprecedented opportunity to showcase high performance principles and optimize building features in an integrated manner. High performance principles and practices applied to site-selection issues, site planning, and design can reap significant capital and operating savings as well as other municipal benefits.

Purpose of these Guidelines

Why do we need them?

With publication of these *Guidelines*, the New York City Department of Design and Construction is stepping up its commitment to integrating *high performance design principles* into the facilities it builds or renovates to house critical municipal services. Increasingly, green building objectives are making their way into mainstream practice in this country through legislative or government agency action, as well as through non-profit, or corporate leadership. Using these *Guidelines* enables DDC to commission high performance public facilities that improve the general standards for good design in the metropolitan region. The *Guidelines* promote both policy and technical strategies for City agencies, designers, and builders. They set out common sense targets for building performance, the means to achieve those objectives, and the necessary tools and references.

Natural Resources Defense Council (NRDC) National Headquarters, New York City
Skylights above the central interconnecting stairs illuminates shared spaces on all three floors. The NRDC headquarters, completed in 1989, was one of the first 'green' renovation projects in New York City.
The Croxton Collaborative
photo: Otto Baitz

The *Guidelines* identify building actions that are practical and cost-effective today. They spell out the benefits and encourage best practices while striving to overcome many of the traditional barriers to optimizing building design.

Who will use them?

The *Guidelines* have been designed for use by *all participants in the New York City capital construction process*, so we should begin by viewing this as a teambuilding process. The initial chapters make the technical performance goals clear and comprehensible to funding and oversight agencies. They encourage client agencies to align high performance building objectives with their service mission, and to select appropriate, attainable goals from among alternative levels of performance. They encourage retooling of conventional programming and budgeting processes, and provide roadmaps for effective change. For elected officials and agency and oversight budget analysts, the *Guidelines* identify costs and benefits, thus encouraging long-term (life-cycle) approaches to capital decisions, as opposed to those driven solely by first cost. For the client end-users, these chapters provide operating staff with tools for a legacy of comfort and economy, along with the means to reduce or eliminate inefficiency, waste, and pollution throughout the building's useful life.

Successful high performance projects depend on obtaining the appropriate green building expertise from the City's private sector partners. These include the consulting architectural and engineering firms contracted for design services, as well as the construction managers, contractors, and tradespeople who accomplish the work. The *Guidelines* help the design and construction team foster multidisciplinary design thinking in order to achieve the lowest end-use cost. At the same time, the *Guidelines* demand new levels of proficiency from consultants and contractors alike in special disciplines such as energy modeling and building commissioning.

The high visibility and symbolic position of a civic facility makes it an excellent forum for educating a wide audience, showcasing new technologies, and adopting innovative business practices. Public works account for a large percentage of the metropolitan region's construction economy. As a significant consumer of technical services, DDC, in commissioning environmentally sound public facilities, will help accelerate the introduction of sustainable building practices, while growing the market for competitively-priced green products. Thus, from an economic development standpoint, proficiency with sustainable concepts, technologies, renewables, and other high efficiency materials and procedures will help ensure the New York City construction industry's continuing prominence in global markets.

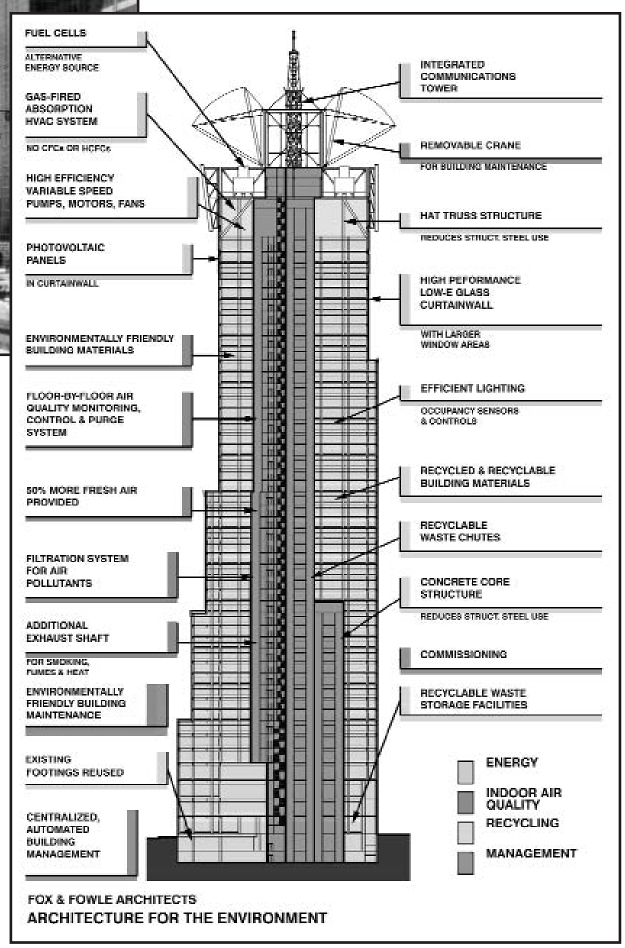
An Overview of High Performance Buildings

What is a 'high performance' building?

New achievers

Many successful new building projects are taking shape throughout the country today, calling into question the performance level of more typical construction endeavors, and prompting us to ask just how far our conventional buildings are falling short of the mark. At the head of the class are a series of energy- and resource-efficient projects that are reaping meaningful energy and cost savings along with important associated benefits. Buildings like the Federal Courthouse in Denver, a new U.S. Environmental Protection Agency facility in North Carolina, the Gap's new San Bruno, California, headquarters, Four Times Square (the Condé Nast building shown on this page), and the Natural Resources Defense Council and Audubon House renovations here in New York City (shown on the previous page) boast numerous value-added features, commonly known as 'green,' 'sustainable,' or simply 'high performance.'

> *"The great news is that enhanced environmental responsibility in high-rise construction does not have to significantly increase the cost of the project."*
>
> **Dan Tishman,**
> President, Tishman Construction,
> *Lessons Learned, Four Times Square*



The Condé Nast Building
This 48-story tower at Four Times Square will be the first project of its size to adopt state-of-the-art standards for energy conservation, indoor air quality, recycling systems, and the use of sustainable manufacturing processes.
Fox & Fowle Architects

Basic objectives

Regardless of terminology, the objectives are the same. From project outset, these building owners, designers, and contractors actively committed to maximizing operational energy savings, providing healthy interiors, and limiting the detrimental environmental impacts of the buildings' construction and operation. As a consequence, they have also leveraged some compelling side benefits. The building occupants enjoy an improved sense of health and well-being that can be attributed to improved daylighting, quality high-efficiency lighting, and better indoor air. Some of these building owners have reported tangible increases in worker productivity. In many cases, these productivity gains have dwarfed the building's combined capital, operations, and maintenance cost savings.[6] These projects' collective successes allow us to pinpoint shortcomings in conventional building standards and construction methods, and to establish realistic, attainable goals.

City of San Diego Ridgehaven Building
The City of San Diego, together with San Diego Gas & Electric, created a showcase for the economic and environmental benefits of green renovation in this upgrade of a 1980's commercial structure.
City of San Diego photo: Adam Saling

DDC high performance buildings – opportunities

DDC's client agencies deliver vital municipal services through such diverse facilities as libraries, cultural institutions, police and fire stations, and health and daycare centers. The various value-added features offered by high performance facilities will complement each agency's mission and enhance service delivery.

The annual energy cost for City facilities is approximately $400 million. By integrating these *Guidelines* into the facility renovation and new construction process, the City can capture operating savings that can then be redirected toward improving building maintenance or enhancing other municipal services. By incorporating environmentally sound materials and systems, improving indoor air quality and daylighting, the City will improve the value of its interior public spaces and realize indirect returns through improved health and well-being of City workers and other building occupants or visitors.

Because these other benefits are more difficult to quantify than direct energy savings, the real value of high performance buildings can be easily be underestimated by traditional accounting methods that do not recognize 'external' municipal and regional costs and benefits. High performance building cost evaluations should address, in some measure, the economic, social, and environmental benefits that accompany green buildings.
(See Part I: Measurable Benefits, p.20).

New South Jamaica Branch Library
A rendering of the first of several DDC showcase high performance projects, now under construction.
Stein White Architects, LLC

6. Romm, J.J., and Browning, W.D., *Greening the Building and the Bottom Line: Increasing Productivity through Energy-Efficient Design*, 1994.

High performance building features and benefits

The following design, construction, and operation activities can result in value-added public buildings. Direct, indirect, and 'external' benefits are also briefly identified and discussed.

☆ Energy Efficiency/Clean Energy Resources

Actions: Reduce energy use and demand through passive solar techniques and integrated building design. This process looks at optimum siting/orientation and maximizes the thermal efficiency of the building envelope (windows, walls, roof) while considering the interaction of the HVAC, lighting, and control systems. Integrated design uses daylight to reduce electrical demand, and incorporates energy efficient lighting, motors, and equipment. It encourages 'right-sizing' of mechanical systems to avoid higher first costs. Where feasible, renewable energy sources such as photovoltaic cells, solar hot water, and geothermal exchange are used in tandem with other low-emission technologies, such as fuel cells.

Benefits: Direct energy cost savings (fuel and electricity) and other life cycle savings yield a good rate of return based on the initial investment. Other external benefits include improved air quality from reduced fuel consumption (limiting nitrous oxide, sulfur dioxide, methane, and other gases that contribute to air pollution). Similarly, reducing the overall aggregate electrical load significantly reduces carbon dioxide emissions, the primary greenhouse gas implicated in global climate change.

☆ Improved Indoor Environment

Actions: Improve indoor air quality by eliminating unhealthy emissions – such as volatile organic compounds, or VOCs – from building materials, products, and furnishings, and through outside filtering and distribution techniques that control pollutants. Improve the thermal qualities and comfort levels of all occupied spaces. Maximize the use of controlled daylighting which can then be augmented by high quality artificial lighting. Provide good acoustic control. Wherever possible, offer occupant the ability to regulate their personal comfort.

Benefits: High performance facilities can help address a wide range of human resource concerns by improving *the total quality of the interior environment.* In addition, attention to building wellness today helps avoid future costs for correcting sick building syndrome. Such 'well building' design emphasis can improve occupant comfort, health, and well-being, in turn reducing employee absenteeism and turnover. The same benefits apply to the facility's public users.

☆ Source Reduction, Pollution Prevention and Recycling

Actions: Where equivalent in quality, cost, and performance, use green building materials and interior furnishings that are made from recycled or renewable resources, are themselves recyclable, and that have been manufactured in a manner least damaging to the environment. Implement construction and demolition (C&D) waste prevention/management strategies and selective site-sorting of materials for salvage, recycling, or disposal.

Benefits: These actions will prevent unnecessary depletion of natural resources and will reduce air, water, and soil pollution. They will also strengthen the market for recycled materials, and the manufacture of products with post-consumer content. Long-term, better C&D waste management can reduce waste disposal costs, ease stress on landfills, and minimize the cost of transporting waste to disposal facilities outside the City.

☆ Building Operations Resource Management

Actions: Design in ways that promote good building operations practices: conserve water using site- and facility-wide measures, create space for everyday waste recycling, and improve housekeeping practices through use of benign cleaning products and more efficient cleaning and maintenance protocols.

Benefits: Water conservation measures will help maintain New York City's water quality and avoid potential future costs by reducing overall loads on water filtration and treatment systems. More efficient cleaning and custodial protocols may increase productivity of custodial staff, while improved housekeeping measures will contribute to overall occupant health and well-being.

Reconciling economics and environmental concerns

> *"Then I say the earth belongs to each...generation during its course, fully and in its own right, no generation can contract debts greater than may be paid during the course of its own existence."*
>
> **Thomas Jefferson**

DDC's building projects – our libraries, firehouses, cultural institutions, daycare centers, courthouses, and other public facilities – bring a wealth of social and economic benefits to our communities. Yet in weighing these benefits, we should also be aware of how our buildings directly and indirectly contribute to environmental and human health problems. Few people in the building trades, let alone average citizens, fully realize the extent to which building construction and operation generates material waste and results in energy inefficiencies and pollution. These so-called 'externalized costs' do not show up on any balance sheet, meaning that the environment – and ultimately society in general – will be forced to absorb them. Every day, buildings squander valuable capital by wasting energy, water, natural resources, and human labor. Most of this waste happens inadvertently, as a result of following accustomed practices that often just meet, but fail to exceed, building codes. Progressive owners, manufacturers, and developers have begun to convert these liabilities into economic opportunities by adopting cost-effective new technologies, processes, and materials that dramatically reduce environmental impacts while increasing profitability.

Hidden costs of construction

As a nation, the price we pay for this sub-par performance ranges from **$10-60 billion** in combined health premiums, absenteeism, and annual productivity losses due to sick building syndrome and building-related illnesses

The hidden costs of construction include the adverse environmental impacts of construction-related activities. Today's design decisions have local, regional, and global consequences. According to the Worldwatch Institute, almost 40% of the 7.5 billion tons of raw materials annually extracted from the earth are transformed into the concrete, steel, sheetrock, glass, rubber, and other elements of our built environment. In the process, landscapes and forests are destroyed, and pollutants are released into the soil, water, and air. Twenty-five percent of our annual wood harvest is used for construction, which contributes to flooding, deforestation, and loss of biodiversity.[7]

Operating a building exacts an ongoing toll on the environment as well. Globally, buildings use about 16% of our total water withdrawals; here in the U.S. that amounts to about 55 gallons per person each day. Buildings consume about 40% of the world's energy production. As a consequence, buildings are involved in producing about 40% of the sulfur dioxide and nitrogen oxides that cause acid rain and contribute to smog formation. Building energy use also produces 33%, or roughly 2.5 billion tons, of all annual carbon dioxide emissions,[8] significantly contributing to the climate changes wrought by the accumulation of this heat-trapping gas.

Today, we are just beginning to understand the high cost of inefficient practices in yet another critical realm: our buildings' interior environments. The U.S. Environmental Protection Agency has ranked poor indoor air quality as among the top five environmental risks to public health, and claims that unhealthy indoor air (which may be two to eight times more contaminated than outside air) can be found in up to 30% of new and renovated buildings.[9] As a nation, the price we pay for this sub-par performance ranges from $10-60 billion in combined health premiums, absenteeism, and annual productivity losses due to sick building syndrome and building-related illnesses.[10]

Municipalities also pay indirect premiums for less efficient, traditionally built facilities. These buildings can impose unnecessary additional burdens on municipal services such as water supply and treatment and solid waste management, indirectly affecting local taxes and municipal budgets.

A 'no-regrets' action

Looking across the full spectrum of conventional building performance, it's clear that our design and construction practices are falling short of what could be achieved with even a small number of strategic, cost-effective corrections. Many industries have a growing appreciation that sound economic and environmental choices are not mutually exclusive, but instead are compatible to the point of being interdependent. This suggests that high performance building practices will be increasingly market-driven as the economic advantages of environmentally sound design and construction continue to gain industry recognition and support. Therefore, implementing these practices should be considered a 'no-regrets' policy initiative that results in economic gain while producing positive environmental results.

7. Roodman, D. M., and Lenssen, N. *A Building Revolution: How Ecology and Health Concerns are Transforming Construction*, Worldwatch Paper 124. March '95 p.22-25.
8. Ibid.
9. Lippiatt, B. and Norris, G. "Selecting Environmentally and Economically Balanced building Materials: National Institute of Standards and Technology Special Publication 888, Second International Green Building Conference and Exposition – 1995 (Gaithersburg, MD) NIST, 1995, 37.
10. Ibid p. 38

Well-integrated design and construction

A whole greater than the sum of its parts

An integrated or 'whole building' design approach requires thinking about the building and its site as a series of interlinked and interdependent systems, so that a single design refinement might simultaneously improve several building systems' performance. Like the domino effect, one refinement can trigger multiple savings or other benefits. For example, careful decisions on building shape and window placement that take into account both prevailing wind and sun angles, may not only enhance a building's thermal performance, but can also result in improved daylighting. These measures will reduce both heating and cooling loads, and in turn, could generate first cost savings achieved through downsizing HVAC equipment and reducing mechanical space requirements.

Using simple, time-honored techniques

High performance designs draw on principles used in much older building practices. As such, they rely on the manipulation of land features, building form, and exterior materials to manage the climate and get the most out of the materials at hand *before* invoking electrical and mechanical assistance from energy-driven heating, cooling, and lighting systems. High performance design also favors 'state-of-the-shelf' technology over sophisticated 'state-of-the-art' equipment. The preference for keeping equipment as simple and maintenance-free as possible is vital to the interests of client agencies, given their limited operating budgets.

Team design

High performance outcomes also demand a much more integrated team approach to the design process and mark a departure from traditional practices, where emerging designs are handed sequentially from architect to engineer to sub-consultant. A unified, more team-driven design and construction process brings together various experts early in the goal-setting process. This helps high performance buildings achieve significantly higher targets for energy efficiency and environmental performance.

A team-driven approach is, in effect, 'front-loading' of expertise. One or more facilitated workshops might involve the owner, design professionals, operators, and contractors (where possible) in a brainstorming session or 'partnering' approach that encourages cooperation in achieving high performance goals while breaking down traditional adversarial roles. During design development, frequent input from users and operators can accelerate progress, eliminate redundant efforts, engender commitment to decisions, reduce errors, and identify synergistic opportunities.

Innovative products and tools

An integrated building design process reexamines the use of traditional products or building assemblies, and identifies innovative technologies or green product and system alternatives that offer significantly improved environmental performance. These progressive design approaches can be further refined through the use of computer energy modeling. Energy modeling simulates the proposed design's response to climate and season. Designers can preview and improve the performance of interdependent features such as orientation, daylighting, alternative building shell design, and various mechanical systems. Energy modeling quickly evaluates cost-effective design options for the building envelope or mechanical systems by simulating the various alternatives in combination. This process takes much of the guesswork out of green building design and specification, and enables a fairly accurate cost/benefit forecasting.

> *"Discovering the DOE-2 model was invaluable. I can't imagine doing this kind of project without it ever again...With this technique, we can actually prove to our clients how much money they will be saving."*
>
> **Robert Fox,**
> Principal, Fox & Fowle,
> architect of Four Times Square,
> *Lessons Learned, Four Times Square*

Current barriers to high performance buildings

The *Guidelines* try to anticipate some of the difficulties that may be encountered in mainstreaming high performance design and construction. The chapters and tools have been designed to help motivate all parties to a capital project, building political will and administrative support for important high performance building investments. Present obstacles include:

- **Steep industry learning curve**

  There is a general lack of knowledge about the economic and environmental benefits of high performance buildings, as well as a dearth of familiarity with green building concepts and practices.

- **Fiscal considerations**

  Current fiscal policies mandate relatively rapid paybacks for energy efficiency improvements. To finance 'deeper' retrofits (system upgrades and improvements to building envelopes), which may yield some initial economic advantages, but much greater operating savings over time, investments with lower rates of return and longer payback cycles should be considered.

- **Barriers to Implementation**

  Departments and funding entities are less likely to sponsor energy- and infrastructure-related programs over higher-visibility improvements such as a playground or new wing. Additionally, the City's energy budget is centralized, so agencies have little motivation to fund and manage efficiency-oriented capital improvements in the absence of specific financial incentives, such as shared savings.

- **Regulatory disincentives**

  The New York City Building Code and the New York State Energy Code each define code compliance in terms of meeting a minimal standard for system performance. In practice, this discourages industry performance beyond the bare bones of code minimum.

Measurable Costs and Benefits

In order to identify the various economic, environmental, and social benefits that high performance buildings will accrue for New York City, a more integrated and consistent approach to measuring these benefits is required. Proposed below is a system for describing project costs/benefits that goes beyond what the City conventionally measures in its capital programs. These costs/benefits are sorted according to how they might impact the various components of the City's **budget:**

- **$\$O$** = Operating budget
- **$\$C$** = Capital budget
- **$\$P$** = Personnel budget

A suffix further identifies the benefit's **primary scope** of influence:

- **F** = Facility-specific benefits
- **M** = Municipal-level benefits
- **S** = Social benefits (shared by society at large)

Thus, if a measure impacts a **f**acility's **o**perating budget, the symbol is **$\$O_F$**. Other benefits are coded as follows:

- **$\$D_S$** = Regional economic development
- **$\$A_S$** = Benefits from reduced air emissions/emissions credits
- **E_S** = External environmental benefits (not quantifiable)
- **G** = General benefits (not quantifiable)

▶ **In each of the following chapters in the *Guidelines,* the relevant benefit(s) are called out using these symbols.**

Symbol	Measurement	Description of Measurable Costs/Benefits
		Facility-Specific Benefits ($_F$)
$\$O_F$	Reduced ***Operating*** Energy Expenditures	Anticipated expense budget operating savings from reduced energy consumption as measured against conventional practices mandated under the NYS Energy Code.
	Operational and Maintenance Savings	Anticipated reduction in facility operating costs through savings in labor, waste handling, and streamlining of housekeeping and maintenance procedures.
$\$C_F$	Incremental ***Construction*** Cost Impact	Line item and/or overall capital construction cost increases/decreases.
$\$P_F$	***Personnel*** Expenditure Reductions	Improved working environment leading to reduced absenteeism and increased employee retention. Potential improvements in performance/productivity.
		Municipal Avoided Costs ($_M$)
$\$O_M$	Reduced Municipal ***Operating*** Expenditures	Diverting of building waste from landfills through construction, operational, and hazardous waste reduction; waste prevention, reuse, and recycling. Savings resulting from water treatment reduction.
$\$C_M$	Reduced Infrastructure ***Construction*** Costs	Avoided capital costs for expanded water supply, sewer systems and wastewater treatment plants.
		Regional Economic Development ($_S$)
$\$D_S$	Economic ***Development***	Indirect economic benefits include reduced expenditure for energy related industries out of state. Development of the clean technologies industry within city and state, making the city and the state an attractive place for clean energy companies to reside. Long-term competitiveness of regional construction industry. Development of local environmentally preferable product markets.
		External Environmental Benefits ($_S$)
$\$A_S$	Emissions Reduction/ Clean ***Air***	Cleaner air through reduced consumption of fossil fuels (reduction of carbon dioxide, oxides of nitrogen, and sulfur dioxide, as well as particulates, mercury.) Accumulated 'emissions credits' from energy efficient public buildings could be tradeable in the future or have monetary value.
E_S	***Environmental*** Benefits	Environmental benefits include climate change stabilization; soil, air and water pollution prevention; preservation of forests and biodiversity.
		General Benefits (G)
G	***General*** Benefits	As noted, these varied benefits are not measureable, such as team building and education of participants in the design process.

Measurable Costs and Benefits from High Performance Buildings

This section describes some of the measurable benefits that can be achieved by integrating high performance measures in New York City public buildings. Explanation of the methods used in quantifying benefits are provided in the Appendix, along with examples of benefits and actual savings realized.

In some instances, we have included benefits of high performance building practices that do not accrue to City agencies. This is due to the fact that a number of these practices make good economic sense, but do not result in any financial savings to the City agency, either because the benefit accrues directly to the City budget or to society in general, or because there is a benefit that would exist if the City altered a particular policy or budgeting practice.

The range of estimated savings presented herein should not be considered as absolute predictions of savings, but rather as guidelines which show the relative weight of savings potential in relation to each other.

I. Facility-Specific Benefits ($_F$)

Range of Savings: $.30–.80 per square foot each year. [14] ◄

A. Reduced Operational Energy Expenditures ($\$0_F$)

High performance buildings with improved envelopes and efficient lighting, equipment, and HVAC systems use less energy than conventional buildings. Potential savings may be measured by determining an annual energy cost budget for a building designed in accordance with these *Guidelines* and comparing it to an energy cost budget for the same building designed to meet minimum New York State Energy Conservation and Construction Code or other baseline requirements.[11] The annual operating budget savings will equal the difference between the respective energy cost budgets.[12] For a typical 100,000 square foot municipal building, a 35% savings in energy use would result in a reduction of up to $70,000 in energy costs each year.[13]

B. Operations and Maintenance Savings ($\$0_F$)

Range of Savings: $.0025–.0050 per square foot each year.[17] ◄

1. Reduced Water Consumption.

Installing water meters in residential buildings and billing for service based on consumption has caused building occupants to diminish their water use by an average of 20%, primarily through conscious efforts to reduce waste (such as repairing leaks).[15] Occupants can further reduce water consumption by installing efficient plumbing fixtures. If all municipal buildings used commercially available water-saving technologies to reduce water consumption by 20% (compared to fixtures meeting the minimum requirements of the 1992 Energy Policy Act [EPACT]), the City could save over $625,000 a year.[16] Actual savings are likely to be even greater, because retrofitting existing buildings will result in replacement of plumbing fixtures installed prior to 1995, most of which use significantly more water than those governed by EPACT.

At present, however, the City pays a flat sum for water use in its own buildings. As a result, reducing water consumption will not result in direct cost savings for individual facilities, but will instead yield financial benefits to the City budget.

Average Savings: $.017 per square foot each year.[21] ◄

2.Reduced Municipal Solid Waste.

City agencies do not directly pay for collection, transport, and disposal of the solid waste they generate, so operations and maintenance (O&M) savings achieved by implementing the waste reduction and recycling measures recommended herein will not directly accrue to the agency (except to the extent that the need to purchase new materials will be reduced). Instead, the City will realize these savings in its Department of Sanitation budget. When the Fresh Kills landfill closes, the City will be forced to pay export fees for all municipal solid waste. The cost of exporting to other landfills is currently $40-60/ton, including transportation but not collection[18] (this cost will undoubtedly rise). By pursuing recycling and waste reduction measures recommended in these *Guidelines*, City tenants in high performance buildings can reduce landfill costs while helping the City reach its recycling goals. In addition, recycled materials from municipal buildings can reap monetary benefits. Depending on the material and current market prices, recyclables can bring revenues of $30-40/ton.[19] If municipal buildings diverted an additional 10% of their solid waste stream to recycling, the City would save nearly $3 million per year.[20]

11. The NYS Energy Conservation Construction Code provides the most simple and straightforward baseline but may not always reflect current industry standards, which often exceed minimum code requirements for energy performance.
12. The exact savings will largely depend on the facility type; i.e., facilities with intensive energy use will save more than those with light energy use. Actual cost savings also will fluctuate from year to year due to variations in weather and energy prices.
13. This calculation is based on a range of energy costs of $1.50 - $2.00 per square foot.
14. This calculation is based on a range of energy costs of $1.50 - $2.00 per square foot and a range of energy savings between 20% and 40%. In private sector buildings energy costs are higher and therefore savings from reduced consumption would be greater.
15. Personal Communication with Rick Diamond and Alan Meier, Lawrence Berkeley National Laboratory 12/8/98.
16. This calculation is based on an estimate of 650 occupants per 100,000 square feet, working 250 days per year, using 20 gallons of water per day. Savings equals the value of water saved at $0.00189 per gallon, less the cost of efficiency measures at $0.00104 per gallon of water saved.
17. This calculation is based on an estimated usage rage of 32.5 gallons per square foot per year, water costs of $0.00189 per gallon, conservation costs of $0.00104 per gallon of water saved, and consumption reduction of 10% to 20%.
18. Communication with DOS Bureau of Waste Prevention, Reuse and Recycling staff, 10/14/98.
19. DOS Bureau of Waste Prevention, Reuse and Recycling, 10/14/98.
20. This calculation is based on figures derived from Department of Sanitation's current Solid Waste Management Plan (see Appendix B).
21. See Appendix B.

3. Improved Maintenance of Buildings.

The City's O&M budgets tend to be set independently of O&M needs. This can result in a large backlog of maintenance and reduce the savings potential of high efficiency systems. Conversely, implementing high performance housekeeping practices and designing buildings for more efficient maintenance can eliminate deferred maintenance and improve the performance and durability of building systems. While not resulting in direct savings to the personnel budget, these practices may have a positive impact on the quality of life for building occupants and maintenance staff, and result in increased productivity. Where no maintenance backlog exists, real operational savings are much more likely.

▶ **Range of Savings:** \$.11–.77 per square foot each year.[22]

C. Construction Cost Trade-Offs ($\$C_F$)

Adherence to the *Guidelines* is likely to result in some discrete first cost savings on certain items. For example, specifying double glazed windows with high performance selective coatings, in conjunction with an energy efficient lighting design, may reduce heat loss and gain to such an extent that it will be possible to downsize the entire HVAC system (chillers, boilers, fans, pumps, ducts, pipes, etc.). Although savings on specific items may be significant, the reduction to the capital budget is likely to be offset by other expenditures, such as the increased cost of high performance windows or measures to assure good indoor air quality. In most cases, adherence to the *Guidelines* will result in a marginal increase to the capital budget as a whole.[23] Following the integrated design and development strategies recommended herein is the best way to maximize the opportunities for cost trade-offs and minimize or eliminate any capital cost premiums.[24]

D. Reduced Disposal Costs for Construction and Demolition Waste ($\$C_F$)

Measures to reduce construction and demolition (C&D) waste include reusing existing structures and materials, avoiding the purchase of excess materials and reducing materials packaging. Reducing waste lowers the cost to contractors who must pay for C&D waste collection and disposal (estimated at \$75.00 per ton).[25] Reducing C&D waste provides a number of additional benefits to the City, as discussed in the Construction Administration chapter. While savings opportunities exist, there is currently not enough consensus on C&D waste data to provide a range of savings.

E. Increased Employee Performance ($\$P_F$)

1. Increased Productivity.

A growing body of case study evidence supports the theory that high performance buildings – those with better lighting, improved ventilation, and fewer air contaminants – are beneficial to employee health and productivity. Although precise methods of measuring these costs and benefits are still in development, the potential for savings is significant. In New York City, annual agency personnel costs vary from \$200-300 per square foot for administrative agencies, to over \$500 per square foot for uniform agencies.[26] A 1% increase in productivity could be worth \$2.00 to \$5.00 per square foot, or up to \$500,000 a year for a 100,000 square foot building.

▶ **Range of Savings:** \$2.00–\$5.00 per square foot.

2. Reduced Absenteeism and Employee Turnover.

Investing in high performance buildings can also help insure against predictable losses in productivity. The New York City personnel services budget is about \$18.4 billion a year.[27] Total equivalent sick leave taken is about 9 days a year. If a healthier work environment reduced the average number of employee sick days taken each year to 8 or 7, the City could realize benefits of \$55 million to \$110 million each year.[28]

Loss of productivity and additional personnel costs occasioned by employee turnover can also be significant, though environmental conditions are only some of the many factors that contribute to the turnover problem. If investing in a better work environment helped the City increase retention by only 1%, the avoided cost of personnel turnover could exceed \$120 million per year.[29]

▶ **Range of Savings:** \$.87–\$1.15 per square foot.*

*This calculation is based on the sum of the range of estimated absenteeism (\$55 million to \$110 million) and increased employee retention (\$120 million), divided by total City owned and leased square footage.

F. Reduced Exposure to Risk of Litigation ($\$P_F$)

Improving the quality of life for building occupants can reduce the City's risk of exposure to litigation related to the work environment, including sick building syndrome, exposure to chemicals and hazardous materials, and accidents resulting from improper maintenance. The growing awareness of – and willingness to take legal action over – illnesses potentially associated with the building environment may increase the City's vulnerability to litigation arising therefrom.

22. This calculation is based on housekeeping and maintenance costs of \$2.30 per square foot and efficiency improvements of 5-35%. Ashkin, Stephen, "Green and Clean: The Designer's Impact on Housekeeping and Maintenance" Proceedings from *The 21st Century Outlook Conference* Technical Papers, American Institute of Architects, 1997, at 186.
23. However, in cases where use of the guidelines results in substantial "recycling" of an existing structure or a decision to forego new construction altogether, savings to the capital budget will likely be substantial.
24. See the Appendix A for Executive Summary from the Environmentally Responsible Building Guidelines Project.
25. Fishbein, Bette K., *Building for the Future: Strategies to Reduce Construction and Demolition Waste in Municipal Projects*, INFORM, June, 1998, page 10.
26. Based on a FY'99 sampling of agencies headcount, square footage and Citywide personnel services information.
27. New York Office of Management and Budget, FY'99 New York budget information.
28. This calculation is based on a 250-day work year and assumes that 75% of the total personnel services budget, or \$13.8 million, is allocated to salary, which results in City payments of \$55 million per day in salary. Reducing absenteeism for all employees by one day is thus valued at \$55 million.
29. This calculation is based on annual salary expenditures of \$13.8 billion, an estimated current turnover rate of 14.29%, and a first-year productivity level of 54.17%, for a citywide productivity level of 93.45%. Reducing turnover to 13.29% would increase city-wide productivity to 93.91%.

Irrespective of any judgments rendered in these types of cases, the City would need to expend considerable resources to investigate and defend against such actions. Adhering to the *Guidelines* can help reduce municipal exposure to litigation by minimizing the likelihood that poor indoor air quality and other environmental problems will occur.

II. Municipal Benefits and Avoided Costs ($_M$)

A. Reduced Services ($\$O_M$)

As noted in the previous section, the City provides water to municipal buildings for a fixed sum and does not charge agencies for waste disposal services. Therefore, the financial benefits of reduced water use and waste generation in City buildings will accrue directly to the City budget.

B. Maintaining and Investing in New Infrastructure ($\$C_M$)

In addition to immediate savings to the operations budget, the City will realize long-term benefits arising out of decreased demand for potable water, wastewater treatment, and waste collection, transfer, and disposal. This is because reductions in the demand for these services allow the City to reduce or delay significant investments in the infrastructure required for provision of such services. Beyond the obvious financial benefits, decreasing our investment in the infrastructure has collateral political benefits. If the City can eliminate the need for a new treatment facility, it will not have to address community opposition to the nuisance engendered by construction and/or operation.

C. Emissions Trading ($\$A_S$)

Reducing energy use in existing buildings has the potential to earn income for the City in its capacity as a building owner. A number of markets exist (or are on the horizon) for emission reduction credits that can be earned by building owners who invest in energy efficiency. New Jersey and five other states have developed open market emission trading programs whereby building owners can generate emission credits by investing in energy efficiency, measuring the electricity saved and determining (based on a prescribed formula) the tons of specified air pollution emissions that were avoided by not generating that amount of electricity. These credits currently sell for approximately \$1,000 per ton for nitrogen oxides (NO_X) and \$2,700 per ton for volatile organic compounds (VOCs).[30] Though not currently open to entities other than utilities, the state and federal cap-and-trade programs for NO_X and sulfur dioxide (SO_2) provide reduction allowances of approximately \$3,000 and \$140 per ton, respectively.[31] If New York adopted an open market trading program for NO_X, a 20% city-wide reduction of energy use in municipal buildings could be worth up to \$1,950,000 per year.[32]

The New York State Department of Environmental Conservation (DEC) administers an Emission Reduction Credit (ERC) program, wherein ERCs can be earned for permanent reductions of NO_X due to decreased end use of fuels (other than electricity). These permanent reductions may be derived from implementation of energy efficiency measures or as a result of switching fuels.[33] As of February, 1999, ERCs are worth \$4,400/ton of NO_X.[34]

From May 1999 to September 2003, the New York State Energy Research and Development Authority (NYSERDA) will pilot an allowance program for NO_X reductions that are achieved as a result of decreased on-site use of electricity during the ozone/smog season (May through September). To qualify, these reductions must be directly attributable to implementation of energy efficiency measures. Eligibility is based on the owner entering into a performance contract with NYSERDA's assistance.[35] As of February, 1999, allowances for emissions trading are approximately \$6,000/ton.[36]

In addition to existing emissions programs, markets are emerging to encourage reduction of carbon dioxide emissions, the primary greenhouse gas. As scientific consensus on climate change grows, there is increasing support for the use of economic measures to help countries achieve their emission targets.

III. Economic Development ($\$D_S$)

An investment in high performance buildings is an investment in New York's future, and is likely to produce indirect economic benefits through development of the nascent clean and efficient technologies industry. This in turn makes the City and the State an attractive place for these technology companies to reside. Statewide, New Yorkers spend approximately \$34 billion each year on the energy required to heat their homes and workplaces, to drive their cars and trucks, and to run the power plants that provide electricity. This figure represents over 5% of the gross state product (GSP).[37] Electricity alone accounts for nearly half of this amount, or \$15 billion.[38]

30. See www.omet.com.
31. See www.epa.gov/acidrain/otc/otcmain for information on NO_X allowance trading and www.epa.gov/acidrain/ats/prices.html for information on SO_2 allowance trading.
32. This calculation is based on estimated current electricity consumption of 3 million MWh per year for municipal buildings, at 1.3 lbs (0.00065 tons) of NO_X per MWh, and \$1,000 per ton of NOx reduced.
33. For more information, contact Radcliff Lee or Burt Breitburg at the DEC Region 2 Office, (718) 482-4944.
34. Cantor Fitzgerald, Environmental Brokerage Services Market Price Index, February, 1999.
35. For more information, contact Karl Michael at NYSERDA, (518) 862-1090, ext. 3324.
36. Environmental Brokerage Services Market Price Index, February, 1999.
37. New York State Energy Research and Development Authority (NYSERDA), *Patterns and Trends, New York State Energy Profiles: 1983-1997*, pages 33-34.
38. Ibid.

To the extent that the City can obtain the same energy services using less energy (through increased efficiency) or through reduced reliance on imported fuel (based on integration of clean technologies such as wind and solar energy), the City will derive social and economic benefits. The first benefit is obvious – improving efficiency reduces energy bills and provides a direct savings to the operating budgets of City agencies each year. The second benefit results when a larger percentage of that $34 billion expenditure stays in New York. Rather than importing fuel from outside sources, New Yorkers will be attracting clean technology businesses to the area and securing the jobs they bring with them. Lastly, all New Yorkers will benefit from the improved air quality that results from reduced combustion of fossil fuels.

Energy and resource efficient buildings also reduce the amount of money that utilities need to invest in fuel, operations and maintenance, and related costs at power plants. Over time, the need to build and upgrade facilities and to expand the transmission and distribution system is reduced, and the resulting savings can be passed on to consumers. Although efficiency services cost money, these investments pay for themselves in energy savings while providing additional benefits that energy production expenditures do not. That's because much of the cost of operating power plants is channeled into fuel and equipment which is largely imported from out of state. In contrast, achieving efficiency is a relatively labor intensive process. Therefore, investments in efficiency result in more jobs and more money retained in the local economy, which in turn contributes to the tax base.

IV. External Environmental Benefits (E_S)

Reducing energy use lowers the emission of oxides of nitrogen (NO_x), sulfur dioxide (SO_2), and carbon dioxide (CO_2) produced by power generation at power plants. These air pollutants contribute to ground level ozone (the primary component of smog), acid rain, and climate change, as well as their related health effects. For example, ground level ozone can cause respiratory problems, especially among the very young, the elderly, and those with respiratory illnesses. NO_x contributes to the formation of particulate matter which is linked to heart and lung disease.[39] Acid rain causes damage to lakes and rivers, as well as to crops and buildings. The appropriate siting of buildings, together with environmentally preferable building materials and products, reduces the impact of real estate development and building use on land and water. By investing in high performance buildings today, the City will be doing its share to solve these problems – a much more cost-effective and well-reasoned approach than paying for remediation efforts later on.

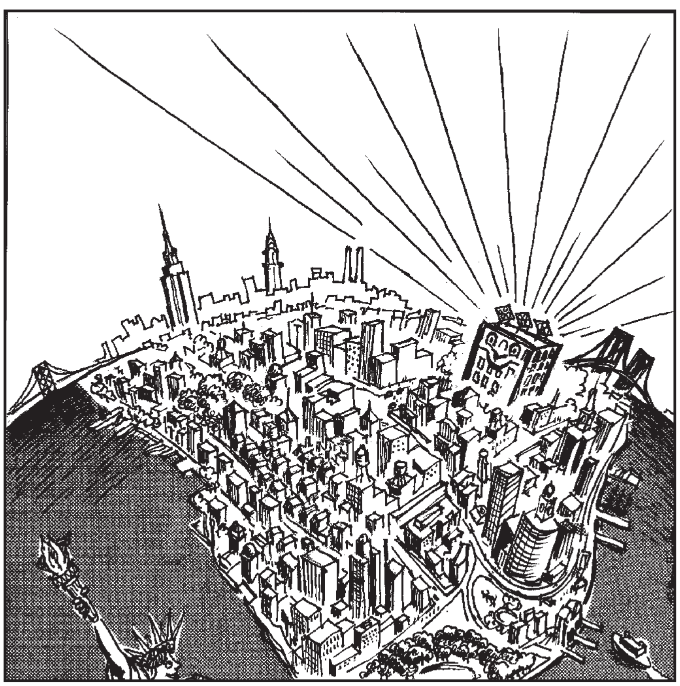


Illustration: Bruce Hendler

39. Natural Resources Defense Council, *Breathtaking: Premature Mortality Due to Particulate Air Pollution in 239 Cities,* 1996.

High Performance

CITY PROCESS

❑ Program Planning
During the capital planning process, the *Guidelines* establish programmatic goals that are consistent with the agency's mission, the intention of the project, and the available budget. Planned work is reviewed against future or past work to ensure that comprehensive work items are identified and that an integrated design approach will not be precluded by funding limitations or phased action of the work.

❑ Site Selection and Planning
High performance attributes are a critical consideration in site selection for a capital project or lease. Adaptive reuse of an existing building may eliminate the need for new construction. The community context of a site and access to services and transportation are as important as the fundamental environmental issues, such as access to daylighting, integration of renewable resources, etc.

❑ Budget Planning
During the executive budget process, high performance building objectives compatible with the agency's goals and the project scope are identified, and appropriate design and construction budgets are established to enable the project to be fully implemented.

❑ Capital Planning Process
The project initiation process, the procurement process, and the interagency and oversight approval processes may all require additional commitment from DDC and the client agency in order to achieve the project's high performance goals.

DESIGN PROCESS

❑ Client Awareness and Goal Setting
High performance objectives are prioritized and weighted to best respond to the client agency's mission and the building's function. Performance goals are established as a means of enhancing the facility's function while advancing the project's environmental and economic objectives.

❑ Team Development
A team approach is vital to the project's success, and will be attained when all sub-consultants are committed to continuous, active participation with the prime consultant from the outset of the project. This 'front-loading' of design input from experts such as landscape architects, mechanical and structural engineers, daylighting consultants, energy efficiency and other 'green' consultants increases cross-disciplinary creativity and encourages problem solving. Client agency executives and members of the maintenance and operations staff will also participate on this integrated team.

❑ Well-Integrated Design
The building's spatial organization should be informed by, and integrated with, its site features and climatic considerations. Collectively, the design of the various interdependent building systems and the envelope should pursue optimal performance at the lowest life cycle cost. New design tools are available to support and reinforce design integration.

❑ Resource Management
Resource conservation begins at the whole project scale where opportunities are greatest. It subsequently applies to individual building systems and materials that may be considered for whole or partial reuse, or for their salvage value. Flexible, adaptable, and generic spaces will increase building utility and longevity as needs change over time.

SITE DESIGN AND PLANNING

❑ Understanding the Site
Inventory and analyze site resources, relationships, and constraints to better enable the designers to maximize energy efficiency while conserving and restoring ecological and cultural resources.

❑ Building-Site Relationship
Taken together, the site design and building design should support the ecological and cultural functions of the entire development. Well-designed open space creates a sustainable microclimate that in turn reduces building energy use and supports a high-quality interior environment. The project as a whole should be designed to minimize negative environmental impacts on surrounding areas and to maximize opportunities to restore natural systems.

❑ Sustainable Landscape Practice
The landscape features must be selected and configured to suit site conditions and restore habitat using self-sustaining landscape design and site maintenance procedures. Practices should promote the conservation and restoration of existing biological and water resources, including species diversity, soil fertility, and aeration.

❑ Encourage Alternative Transportation
The site should offer support facilities for bicycling, mass transit, electric vehicles, carpooling, and other less-polluting means of transportation.

BUILDING ENERGY USE

❑ Site and Massing Considerations
Taking advantage of the physical features of the building site and microclimate will reduce heating and cooling loads, thereby lowering overall energy consumption.

❑ Interior Layout/Spatial Design
An appropriate layout of program spaces will help reduce energy consumption and will promote the use of passive solar heating and cooling.

❑ Building Envelope
Appropriate assembly of wall, roof, foundation, and window materials will provide good thermal and moisture control, while supporting reductions in building energy use. A good envelope harnesses natural energy through effective use of passive solar and daylighting techniques.

❑ Daylighting/Sun Control
Whenever possible, controlled daylighting should be incorporated into the building as the preferred mode of interior illumination and to reduce lighting load and operating costs. This saves the most expensive form of energy we use: electricity, and the charges associated with peak demand.

❑ Light Pollution
Sensitive site lighting will reduce light pollution in the sky, between buildings, and in open spaces, thus avoiding negative impacts on plants, animals, and people. Good lighting design also reduces energy waste while improving night views of the sky.

❑ High Performance Lighting
A highly efficient light level distribution that improves visual quality while reducing electrical use may be achieved through efficient lighting layout, lamps, luminaires, and other components, together with localized lighting controls. Use fixtures that minimize the use of hazardous lamp materials.

❑ Electrical Systems and Equipment
Efficient design strategies, power distribution systems, and electrical equipment can increase building's energy efficiency and reduce energy consumption and associated costs.

❑ Energy Sources
Various energy sources are available today. Designers should first capitalize on conservation techniques, then work to achieve an appropriate, integrated balance of solar heating, daylighting, energy entrained within the earth (geothermal energy), air movement, and other renewable resources. Only then should they resort to fossil fuel technologies, seeking efficiencies in this realm as well. This integrated approach to whole building design reduces the production of greenhouse gases, smog, and acid rain; preserves natural resources; and slows the depletion of fossil fuel reserves.

❑ Mechanical Systems
Mechanical systems must work in concert with the building layout, orientation, envelope, lighting strategies, electrical equipment, and site characteristics to reduce reliance on energy derived from fossil fuels, and to increase the use of renewable energy.

Building Objectives

❑ **Energy Load Management**
The management, continuous calibration, and maintenance of energy-related systems is often neglected, yet these are the only ways to optimize the life and performance of the systems and minimize the damage caused by fossil fuel use. Effective energy load management is a two-step process, consisting of load measurement and system response. Continuous calibration of sensors and instrumentation will yield top mechanical system performance in terms of energy use and comfort.

INDOOR ENVIRONMENT

❑ **Good Indoor Air Quality (IAQ)**
A healthy and comfortable level of indoor air quality is the goal for all occupied spaces, as good IAQ supports and enhances the activities and well-being of the occupants.

❑ **Light Sources**
Achieve a quality of light that is beneficial to building activities and occupants by combining natural light with complementary electrical light sources.

❑ **Noise Control**
Create a sound environment that is healthful, comfortable, and appropriate to intended use by controlling noise and carefully attending to the acoustic design of spaces.

❑ **Controllability of Systems**
To achieve a healthy and comfortable environment, it is critical to ensure that user groups and facility maintenance staff can knowledgeably operate the building systems and equipment. As much control as possible should be given to individual users, without compromising the effectiveness and efficient control of the overall system.

MATERIAL AND PRODUCT SELECTION

❑ **Selection for a Healthy Indoor Environment**
Overall indoor air quality goals can be achieved by specifying and installing benign, or 'healthy' building materials. These include materials and products that exhibit limited or no 'off-gassing' tendencies, have minimal or no toxic properties, do not shed dust and fiber, and do not absorb pollutants that are later released, potentially generating complaints among building users/occupants.

❑ **Selection for Resource Efficiency**
Resource efficiency can be achieved through conscientious design strategies, and by selecting environmentally preferable building materials. These measures can conserve natural resources while minimizing the generation of waste and pollution during construction. The hierarchy of 'reduce, reuse, recycle' can serve as a guideline for decisions relating to resource efficiency.

❑ **Selection for External Environmental Benefit**
The selection and use of environmentally preferable materials yields benefits that easily exceed the scope of the building itself. Products produced and deployed in an environmentally responsible manner help reduce local, regional, and global pollution while encouraging sustainable stewardship of resources. For example, global benefits accrue from specifying sustainably harvested, certified wood products, and from avoiding the use of ozone-depleting compounds in foam products, refrigeration and fire suppression systems.

WATER MANAGEMENT

❑ **Minimize the Use of Domestic Water**
Proper selection of plumbing fixtures, equipment, and fittings can minimize end use of domestic water while conserving water quality and availability.

❑ **Water Quality**
All projects must ensure optimal water quality at the tap – potable water that is both safe (non-toxic) and aesthetically pleasing in terms of taste, color, and odor.

❑ **Water Reuse**
To achieve overall water conservation goals, it is important to limit the use of potable water for non-potable purposes. On site water reclamation and reuse should be encouraged and facilitated wherever possible.

CONSTRUCTION ADMINISTRATION

❑ **Environmental and Community Considerations**
Renovation and new construction should be performed with the least possible disruption to both the community and the environment. Conscientious construction administration can minimize harm to the site and surrounding area, including soil, water resources, and air. Construction of the project should foster the perception of high performance buildings as good neighbors.

❑ **Health and Safety**
Construction workers and building occupants need protection from pollutants produced during construction, such as volatile organic compounds (VOCs), particulates, dust and other airborne contaminants and odors. These same construction contaminants must also be prevented from accumulating in building HVAC systems and in absorbent building materials, such as carpet and furnishings.

❑ **Construction and Demolition Waste Management**
Construction and demolition (C&D) waste management techniques divert materials from the waste stream, thus preserving valuable resources and landfill space. C&D waste typically includes building demolition and scrap materials, components such as doors or lighting fixtures, packaging materials, hazardous materials, and miscellaneous construction waste such as bottles, cans, or paper.

COMMISSIONING

❑ **Fully Integrated Operating Systems**
Commissioning activities transform the various building systems into an integrated whole. During all tests and performance protocols, a dedicated commissioning agent oversees the building team to ensure that the systems have been well-designed, appropriately installed, and functionally tested, and that the staff are trained to operate and maintain the facility in conformance with design intent.

❑ **Commissioning Existing Buildings**
For a building renovation or infrastructure upgrade, commissioning should be performed on the affected systems or parts of systems in a comprehensive manner.

OPERATIONS AND MAINTENANCE

❑ **Operating and Maintaining Building Systems**
Operating and maintenance practices ensure that all building systems function to the fullest extent of their designed efficiency and meet specified levels of energy and indoor air quality performance. Scheduled maintenance and cleaning will help to yield ongoing energy savings for the building while promoting occupant health and comfort.

❑ **Healthy and Efficient Custodial Operations**
Reduced human exposure to physical and chemical hazards and odors associated with cleaning products and pesticides can be achieved through custodial operations that employ appropriate methods and low-toxicity or non-toxic cleaning products.

❑ **Waste Prevention and Recycling**
Reducing, reusing, and recycling solid, liquid, and food waste from day-to-day building operations and activities are critical high performance operating strategies, in that they effectively promote ongoing resource conservation. Purchasing decisions can also contribute to waste prevention (e.g., specifying mechanically-controlled roll towels instead of disposable folded towels; avoiding products with excessive or unnecessary packaging).

Part Two: Process

City Process

Strategic planning and budgeting supports the development of high performance buildings.

At project outset, the client agency must embrace a vision of raised expectations for the building's performance and a commitment to the 'total quality management' approach to developing high performance buildings. During site selection, programming, and budgeting, enhanced decisionmaking with input from multiple stakeholders is the order of the day. Executives must ensure active participation on the part of program staff, operations and maintenance personnel, and other prospective users. As a team, they will take into account community and environmental impacts of their project. They will consider the project's present and future anticipated capital requirements. They must seek to optimize the design process through constant participation, examination, and refinement, and to pursue a philosophy of meticulous contract enforcement. Knowledge and awareness of inter-agency and oversight procedures can streamline the project and enhance its performance goals. The benefits of this approach to the client agency include reduced operating costs, avoided costs of future maintenance and repair, and higher quality program spaces in which the agency can best carry out its mission.

City Process

Benefits ◄

C_F

Accurate needs forecasting and programming may eliminate redundant or unnecessary construction efforts.

Program Planning

During the capital planning process, the *Guidelines* establish programmatic goals that are consistent with the agency's mission, the intention of the project, and the available budget. Planned work is reviewed against future or past work to ensure that comprehensive work items are identified and that an integrated design approach will not be precluded by funding limitations or phased action of the work.

Technical Strategies (for Client Agencies)

- ❑ **Planning meeting.** Early in the capital budget cycle, convene a planning meeting involving all capital staff, operations personnel, and program staff, etc., to identify and further develop high performance objectives as drawn from these *Guidelines*. *(Refer to Appendix C, The High Performance Building Workplan).* With these objectives in mind, discuss and prepare the High Performance Project Initiation Form.[40] *(Refer to Appendix D)*
- ❑ **Make use of the City's Asset Information Management Survey (AIMS)[41] data.** Evaluate the project's relationship to other current and anticipated capital improvements at the facility so as to make informed decisions on related work, or on the phasing of future work. Examine interrelated systems that may be nearing the end of their useful life for possible inclusion in the project scope. Where AIMS data is outdated, request a new survey from OMB.[42]
- ❑ **Properly sequence the work.** Sequence renovations and upgrades to obtain best long-term performance and operating economies. Best practices mandate improving the thermal performance of the building envelope before or concurrent with the upgrade of mechanical and electrical systems *(see renovation strategies p.11).*
- ❑ **Non-construction or reduced construction options.** Consider non-construction or reduced construction options to achieve the same program ends. These include:
  - Examining redesign/reuse of existing or alternate city-owned facilities as a means of eliminating new construction;
  - Downsizing the program by identifying economies or redundancies, or altering operating schedules to accommodate more effective uses of the built spaces; and
  - Consolidating with other projects.
  - Evaluate each option in terms of total life cycle costs, including short and long term capital costs, operating costs, and the avoided costs of new building site acquisition, demolition, and infrastructure. To best address resource efficiency concerns, identify other projects that could effectively be combined with this one.
- ❑ **Multiple use opportunities.** Consider additional program uses for the facility. Explore the potential for expanded uses (now or in the future) that might be compatible with those of the current project, and design with flexibility and adaptability in mind.
- ❑ **Alternative space standards.** Examine space planning and programming standards to encourage more flexible solutions. Consider, for example, using single spaces for multiple purposes. Consider the use of standardized (universal) rooms or spaces to avoid design obsolescence as the organization evolves over time, and minimize the cost of any future modifications. Approach the program as a list of activities or functions to be accommodated, rather than as an absolute, predetermined list of spaces.
- ❑ **Application to leased space.** Consider the use of the *Guidelines* in conjunction with any leasing of spaces. Whenever possible, request that high performance objectives be included in the lease negotiations.

40. See Appendix, item D
41. Asset Information Management Survey, published yearly; includes condition and maintenance schedules for major portions of the City's fixed assets and infrastructure.
42. Contact OMB or agency liaison for a copy of the report.

Site Selection and Planning

High performance attributes are a critical consideration in site selection for a capital project or lease. Adaptive reuse of an existing building may eliminate the need for new construction. The community context of a site and access to services and transportation are as important as the fundamental environmental issues, such as access to daylighting, integration of renewable resources, etc.

Technical Strategies

Site Selection

- ❑ **Evaluate site resources.** Evaluate existing building and site resources and select a site with characteristics that are conducive to optimum performance. Consider:
  - Compatible facilities and sites currently under the City's auspices or control that are either fully available or are not being used to the optimum effect. Research available City-owned space.
  - Avoid selecting 'greenfield' sites (desirable open spaces; parklands; places of significant ecological, cultural, or historical value; places with unique visual appeal).
  - Reuse 'brownfields.' Where economically feasible, select sites that provide opportunities to remediate or repair existing environmental damage ('brownfield' conditions include polluted soil, water, and air; degraded vegetation; etc.). Brownfield reuse also helps reduce sprawl.
- ❑ **Transportation/services.** Select sites that are well serviced by existing public transportation, utilities, and related municipal services. This reduces site development costs and lessens environmental impacts. Select sites that already have, or have the potential for, amenities such as restaurants, shopping areas, pleasant views, etc.
- ❑ **Future growth.** Select sites that allow for future growth or expansion by the client agency or end user.

Site Context and Community Issues

- ❑ **Environmental justice.** High performance projects take environmental justice issues into account in site selection. These include maximizing economic viability and opportunities for employment, introducing or preserving cultural benefits for the community, and minimizing adverse environmental and infrastructure impacts on the neighborhood. Consideration should be given as to whether the community already has more than, or enough of its 'fair share' of similar facilities.
- ❑ **Environmental opportunities.** In preliminary zoning reviews, identify the site's environmental advantages, such as solar access, lot area coverage, and available modes of transportation.
- ❑ **Environmental deficiencies.** When reviewing a site, evaluate adverse environmental conditions, such as air pollution, noise, and barriers to accessibility.
- ❑ **Green buildings as 'good neighbors.'** Determine the appropriateness and compatibility of the facility to the surrounding environment in terms of use, activity level, and traffic considerations. Identify negative impacts and formulate potential mitigation strategies.
- ❑ **Shared use.** Consider how the site may provide opportunities for shared use or access needs to nearby public programs; e.g. day/night parking and sharing of assembly spaces.
- ❑ **Community outreach.** Develop an action plan for community outreach to promote the high performance building and to address community and context issues. Encourage participation by elected and appointed officials and other community stakeholders.

Riverbank State Park
The North River Sewage Treatment Plant was located adjacent to a densely populated residential neighborhood. Design and installation of a State Park, with a running track, skating rink, pool and gymnasium, as well as the inclusion of taller exhaust stacks, helped lessen the impact of this facility on the community.
photo: Stephen Campbell

▶ **Benefits**

$$C_M$
Strategic siting can reduce stress on, or eliminate unnecessary expansion of, utilities and other infrastructure components (e.g., roads, parking lots).

$$D_S$
Careful study of context in facilities planning may help reduce negative environmental impacts. Strategic siting of the facility may have positive economic effects on the surrounding community.

City Process

Washington Heights Day Care Center – Site Selection Process

The site originally selected for this community facility was too small for the program. It was very narrow, and did not have immediate access to outdoor open space. As such, the site would have required the development of a six-story day care center, special approvals from the Department of Transportation, and development of a portion of public park land into child care open space. Although the site was apparently the only one available, careful re-examination of the catchment area and alternative ways of addressing the needs of the community engendered a unique cooperation between the community and nearby Columbia-Presbyterian Hospital.

Budget Planning

Benefits ◄

G
Adequate budgets will eliminate unnecessary project delays.

During the executive budget process, high performance building objectives compatible with the agency's goals and the project scope are identified, and appropriate design and construction budgets are established to enable the project to be fully implemented.

Technical Strategies

- ❑ **Design planning.** Establish a design budget that is sufficient to achieve the scope of work, taking into account all aspects the high performance design process and deliverables as described in the Design Process chapter. The design budget should reflect the cost of all services and deliverables for: a) development and implementation of the High Performance Plan; b) implementation of energy use modeling and/or daylighting modeling; c) more extensive life cycle costing as an aid to decisionmaking during design; d) more intensive monitoring by consultants during construction; and e) development of an Owner's Manual at the conclusion of the project.
- ❑ **Construction planning.** Allocate a construction budget sufficient to achieve Level 1 and selected Level 2 high performance goals. Additional capital costs may be offset by life cycle operational savings. Consider including a budget for commissioning as appropriate.[43] See the Commissioning chapter for more information on inclusion of this important process.
- ❑ **Plan for operational savings.** Look ahead to establish an Energy Budget. Coordinate with DCAS/OEC. Use data derived from existing facilities or comparable building types to establish the baseline budget from which attainment of energy performance goals will be measured.

Capital Planning Process

Benefits ◄

G
Ensuring adequate interagency coordination can eliminate planning errors and costly delays.

The project initiation process, the procurement process, and the interagency and oversight approval processes may all require additional commitment from DDC and the client agency in order to achieve the project's high performance goals.

Technical Strategies

- ❑ **Project initiation.** The client agency must complete the High Performance Project Initiation Form, which highlights strategies and considerations for achieving a better project.
- ❑ **ULURP/EIS.** During the Uniform Land Use Review Procedure (ULURP), make use of regulatory procedures such as Environmental Impact Statements (EIS), City Planning review and Community Board review as high performance planning resources.
- ❑ **Interagency and oversight approvals.** When requesting reviews or support, the client agency must ensure that the Office of Management and Budget, the Mayor's Office of Construction, Comptroller, and other oversight entities understand that the project is a high performance project.
- ❑ **Procurement.** To obtain necessary high performance expertise, DDC and the client agency must select consultant lists and establish weighted criteria for subconsultants.

43. Current industry costs for commissioning services range from 0.5% and 3% of the construction budget depending on building type, size, and extent of services.

❑ **Scoping.** Additional focus on and detailed attention to the *Guidelines* should take place during DDC's development of the Specific Requirements and the Request for Proposal.

❑ **Client agency staff commitment.** Achieving a high performance building requires additional intra-agency and interagency cooperation during the planning and design phases. Appropriate staff must be made available and adequate staff time must be allocated.

PERFORMANCE GOALS

City Process

❑ Utilize existing infrastructure.

❑ If an existing building is to be rehabilitated, maintain and reuse 75% to 100% of the existing building's structural shell.

Tools

➤ Asset Information Management Survey (AIMS) is available from the Office of Management and Budget.

➤ Building Momentum, Energy Star. The Environmental Protection Agency's *Energy Star Building Program* provides managerial and technical tools to commercial building owners to improve the efficiency of their buildings, from appropriate organizational strategies, through the development of baselines and analyses, to securing funding, implementing upgrades and celebrating success.

Deliverables

❍ High Performance Building Project Initiation Form

❍ High Performance Building Workplan

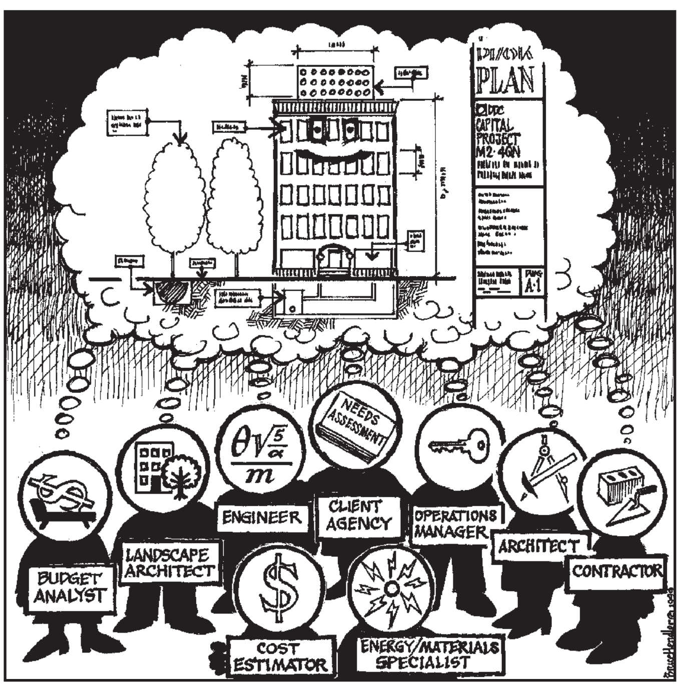


Illustration: Bruce Hendler

City Process

Design Process

The delivery of a high performance project calls for significantly increased collaboration among the various design disciplines. A focused goal-setting session will help develop a work plan for incorporating high performance objectives. The emphasis on interdisciplinary design and resource management, together with use of new design tools, distinguishes high performance from conventional processes.

Design thinking should be informed by the traditional efficiency methods and techniques employed by older or vernacular buildings, where forms, building materials, and means of achieving comfort respond to local climate and acknowledge the location of the sun. When taking advantage of the increasing sophistication of today's building systems and material technologies, high performance designers should temper their selections and specifications to minimize dependence on mechanical and architectural technologies that are difficult to manage and maintain.

Design Process

Client Awareness and Goal Setting

Benefits ◄

G
Helps establish and build lasting commitment to high performance goals.

G
Promotes team's commitment to design methods and tools which in turn promotes attainment of goals.

High performance objectives are prioritized and weighted to best respond to the client agency's mission and the building's function. Performance goals are established as a means of enhancing the facility's function while advancing the project's environmental and economic objectives.

Technical Strategies

- ❑ ***Guidelines* implementation.** During the scope development phase, the City's project team, together with the client agency, identifies which general objectives and technical strategies are to be incorporated into the project's Specific Requirements (SR).

> **Goal Setting**
> In setting goals for a senior center, the sponsor might identify daylighting and optimal artificial lighting as high performance priorities. Daycare centers might instead emphasize indoor air quality, increasing fresh air ratios in classroom or play spaces, and reducing or eliminating VOCs from construction materials.

- ❑ **Goal setting workshops**. With the consultant on board at the project inception, the full client team, together with the consulting team, shall participate in a 'charrette'[44] or goal setting workshop to establish and integrate high performance goals in relation to other project priorities.
- ❑ **High Performance Plan.** Based on these workshops, the consultant will prepare a deliverable called the 'High Performance Plan' which sets environmental and energy performance goals for the project. This Plan should be updated to reflect iterative changes during design and enable measurement of overall project achievement.
- ❑ **High performance 'education'.** The high visibility and symbolic position of a civic facility make it an important public showcase for sustainable design. Consideration should be given early in the project as to how the building's design itself can illustrate the benefits of high performance attributes while supporting the key mission of the client agency. The high performance building features themselves can be designed evocatively to explain their benefits. Alternatively, special exhibits or artwork commissioned by the client agency can illustrate or complement these attributes.

Team Development

Benefits ◄

G
Raises level of expertise within the design community on interdisciplinary high performance issues and strategies.

G
Enables effective decisionmaking during the predesign phase, when efficiency strategies can be implemented at lowest possible cost.

"Because the stage was set for environmental awareness and innovation, everyone else on the team got on board, immediately thinking along the same lines: manufacturers, contractors, suppliers, and utility company."

Dan Tishman,
President, Tishman Construction,
Lessons Learned, Four TImes Square

A team approach is vital to the project's success, and is attained when all sub-consultants are committed *to continuous, active participation with the prime consultant* from the outset of the project. This 'front-loading' of design input from experts such as landscape architects, mechanical and structural engineers, daylighting consultants, energy efficiency and other 'green' consultants increases cross-disciplinary creativity and encourages problem solving. Client agency executives and members of the maintenance and operations staff also participate on this integrated team.

Project Team Design Charrette,
New Children's Center,
NYC Administration for Children's Services
For the renovation of a historically designated building into a staff training center and intake facility for children, a design charrette brought mechanical engineers, historic preservationists, and energy and green building consultants together early on to identify solutions and share ideas. This facilitated improvement of the building's central heating and cooling system, thereby achieving energy savings without any adverse impact on the building's exterior.
Photo: Rick Bell, DDC

44. The charrette process is one or more facilitated workshop(s) which helps educate all the team members in the high performance issues, develop team consensus on the primary goals, and develop "buy in" to the solutions recommended.

Technical Strategies

- ❑ **Specific sub-consultant participation.** The Specific Requirements and RFP should state the level of participation expected of each sub-consultant at each phase to clearly delineate their contributions to achieving an integrated design.
- ❑ **Consultant selection.** DDC and the client agency must review procurement options to determine appropriate means of selecting the best pre-qualified consultant and sub-consultants. They will establish selection criteria, weighting, pre-qualified lists, or other methods of incorporating green building expertise in project development. Expertise in such disciplines as acoustics, horticulture, industrial hygiene, etc. may also be required.
- ❑ **Goal setting workshops.** All team members participate in goal setting workshops (‘charrettes’) and/or milestone meetings with the client, which will establish key features of the project and performance targets.

Well-Integrated Design

The building’s spatial organization should be informed by, and integrated with, its site features and climatic considerations. Collectively, the design of the various interdependent building systems and the envelope should pursue optimal performance at the lowest life cycle cost. New design tools are available to support and reinforce design integration.

▶ **Benefits**

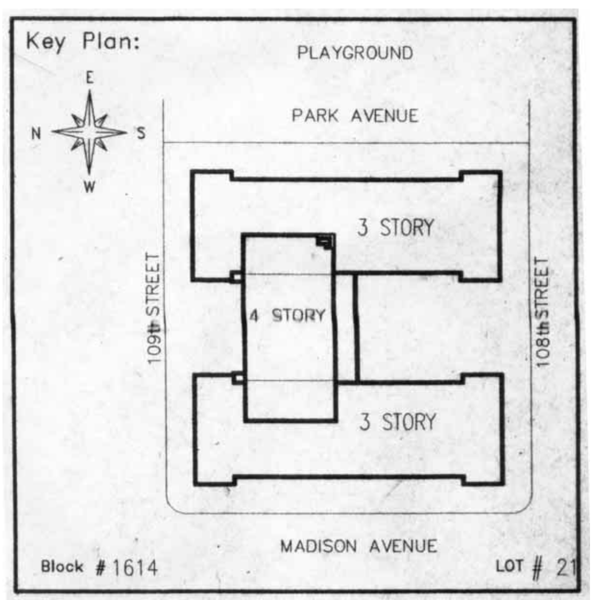
O_F
Maintenance and operating savings can be achieved through optimization of several building systems at the same time.

C_F
Integrated design can achieve reduced building system first costs by allowing for downsizing of some building systems (i.e., improved glazing and insulation can reduce HVAC demand).

G
Climate-responsive, ‘whole building’ design can often enhance the visual interest of the building.

Technical Strategies

- ❑ **Design integration.** Sub-consultant participation in design strategy development will enable cross-disciplinary decisionmaking relative to building siting, configuration, building envelope and HVAC design. Integration fosters a perception of the building as a set of *interrelated, interdependent systems* wherein a single solution can trigger improvements in several other building systems simultaneously. In this way, multiple savings and other benefits may be attained.
- ❑ **Modeling.** Use computerized or other appropriately detailed spatial representations of the building and site to provide continuous feedback on the integrative functionality of all design components. Specifically, use computerized energy modeling to integrate architecture and engineering decisional processes and to explore the life cycle cost advantages of multiple design alternatives for the envelope (insulation, glazing, curtain walls, roof, etc.) and for the mechanical and lighting systems.
- ❑ **Cross-disciplinary design.** Ensure appropriate cross-disciplinary teamwork in achieving the necessary integration of building site, systems, and operations.
- ❑ **Reference to high performance objectives.** Periodically, and not less than at each milestone, the project team should update the initial High Performance Plan to assure the integrity of the goals and objectives.



High Performance Attributes in Older Buildings
Historic buildings often exemplify integrated design by achieving comfort with an economy of means and without dependence on sophisticated mechanical and electrical systems.

For example, many early 20th Century New York City schools were constructed with C- or H-shaped floor plans, thermally efficient masonry walls, large built-in ventilation shafts, and operable transoms in the corridors. These features control temperature swings, maximize daylighting, and encourage cross-ventilation. Other historical examples include use of exterior courtyard spaces or rooftop terraces for summertime reading or dining, and activity areas in public libraries.

Resource Management

Benefits ◀

$\$C_F$
First cost reduction (avoided demolition, super-structure costs).

$\$C_F$
Longer system replacement cycle.

$\$O_M$
Material conservation reduces waste management costs.

E_S
Building and building fabric re-use reduces consumption of new resources.

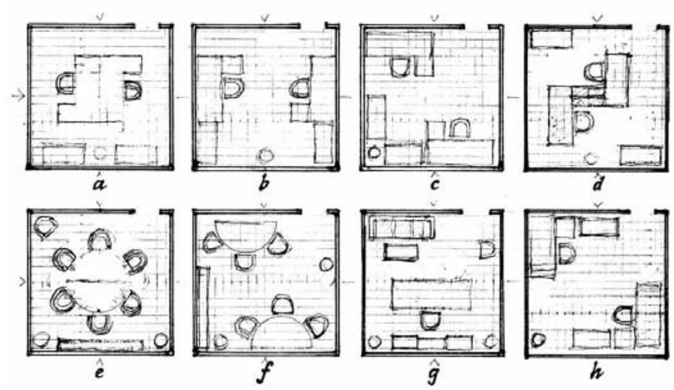
G
Preservation of architectural and urban fabric embodied in older buildings.

Resource conservation begins at the whole project scale where opportunities are greatest. It subsequently applies to individual building systems and materials that may be considered for whole or partial reuse, or for their salvage value. Flexible, adaptable, and generic spaces will increase building utility and longevity as needs change over time.

Technical Strategies

❑ **“Right-size” the space program.** Make sure that space assignments are optimally sized by considering the following:

- *Multiple uses* for individual spaces; i.e., a single space used for various functions at different times.
- *Alternative officing*, whereby unassigned, flexible workstations are shared by multiple users.
- *Universal sizing* (design that incorporates standardized room or workstation sizing).



Building for Future Flexibility
A new building floorplan should have uniformly sized (modular) spaces, with as many as possible of the same (universal) size. When the organization or use changes, people may then be easily retrofitted into these generic spaces.
Illustration: Bruce Hendler

❑ **Waste prevention.** Survey the existing facility’s materials and systems for potential refurbishment and/or salvage value.

❑ **Minimize construction interventions.** When approaching a building renovation, consider creative programming changes that avoid unnecessary reconfiguration.

❑ **Future adaptability.** Use ample floor-to-floor heights (interstitial spaces) to allow for future modification of mechanical, electrical, plumbing, and communications systems. Select building systems that allow for future adaptability and expansion, and provide adequate floor loading.

❑ **Future waste streams.** Design for building longevity and durability, and to extend replacement cycles. Detailing for easy disassembly will reduce future demolition waste and renovation costs.

Surrogates Court
In adaptive reuse of older building stock, high quality interior materials should be salvaged and refurbished rather than discarded. The interior of this courtroom in the Surrogates Court in lower Manhattan exemplifies an array of materials.

Reuse of Building Systems
A ‘weatherization’ project might consider window refurbishment (caulking, sealing, and use of insulating windows), rather than installing all new windows. While more labor intensive, this decision avoids material waste and may be further justified because window replacement by itself may have a long payback period.

PERFORMANCE GOALS (NEW CONSTRUCTION AND RENOVATION)

Design Process

- ❑ Complete and implement the High Performance Plan.

Tools

- ➤ US Green Building Council LEED Rating System, www.usgbc.org
- ➤ Green Building Challenge '98 Rating System, www.eren.doe.gov/buildings/gbc98/green_building_challenge.htm

Deliverables

The High Performance Plan – A Key Deliverable in the Design Process

The High Performance Plan (the Plan) spells out the means for integrating high performance features into the project. The Plan will be formulated by the consultant during the pre-preliminary phase of the project. Where the project does not have a pre-preliminary phase, the Plan will be delivered during the schematic phase.

The consultant should also identify additional deliverables to be specifically required in subsequent project phases. These are described in detail in ensuing chapters. The Owner's Manual, a deliverable to be submitted by the consultant upon final completion of construction, is described on p.40. *All* deliverables and key submittals relating to high performance aspects of the project are summarized by project phase and chapter in the "Summary Table of High Performance Key Submittals and Deliverables," which is located on p. 42.

The deliverables to be included in the High Performance Plan during the pre-preliminary/ schematic phase of each project are described below.

1. Implementation Strategy. Utilize the *High Performance Building Guidelines* as a tool for developing an overall strategy customized to suit each project. The specific performance objectives and technical strategies should be identified and defined during a facilitated workshop with the entire project team, including the consultants, sub-consultants, client agency representatives, building users, and DDC personnel. The Plan will include a record of this process that should be referred to on a regular basis during the design phases. This portion of the Plan should include but not be limited to the following:

- Listing of selected high performance *objectives* that are consistent with the client agency's mission and which relate to opportunities presented by the project.
- Appropriate *technical strategies* for achieving the selected objectives.
- High performance *key submittals and deliverables* selected from *Guidelines* chapters that relate to the objectives, technical strategies, and performance goals.
- Schedule of milestones for high performance deliverables, key submittals, decisions, and meetings. This schedule will be integrated with the overall project schedule.

2. Site Opportunities. As appropriate, perform the analyses and identify site-related opportunities described in the Site Design chapter as follows:

- Analysis of bio-climate, including solar access diagrams, prevailing wind analysis, and identification of appropriate passive solar and natural ventilation strategies and their means of development.
- Analysis of existing and potential topographical and landscaping features that will help reduce energy load.
- Analysis of existing site characteristics such as views, adjacent open spaces and environmentally sensitive areas, vegetation, seasonal flooding, exposure to seasonal storms, high winds, and wildlife habitat, as well as identification of appropriate responses to identified conditions.

- Analysis of opportunities for mitigating the urban heat island effect[45] and urban light pollution.
- Analyses of urban/historical/cultural context, community resources, land use patterns, and architectural styles. Identification of project attributes that should be protected, conserved, or restored.
- Analysis of subgrade characteristics and suitability for plant life. Analysis of suitability for geothermal applications.
- Analysis of mass transit/bicycle access to site and opportunities to encourage same.

3. Operating Energy Analysis. Prepare a preliminary energy plan that includes the following:

- Analysis of energy use in similar building types. Gather information on the energy use of comparable high performance buildings and apply this in developing the project's performance goals. Standard industry practices should also be identified for use as a baseline for measuring the effects of proposed improvements. For renovations, analysis of the previous three years of monthly energy consumption (including gas, oil, electric usage, and electric demand) would serve to establish a baseline against which improvements may be compared.
- Performance goals for operating energy costs based on the above analysis.
- Performance goals for renewable energy use, as well as possible forms of renewable energy to be used.
- Proposed methodology for simulating and analyzing energy performance of the building design, including identification of appropriate energy modeling software.
- Goals for lighting and power density for the project as a whole and for all major spaces. Lighting and power density should each be reported in two ways: first as the amount available for use and second as source of potential heat gain.

4. Environmental Program Matrix. Prepare a matrix describing preferred conditions *for each major type of space* in the project space program. *(See sample document included as Appendix F).* These conditions should include:

- Indoor air temperature, relative humidity, and mean radiant temperature.
- Air changes in cubic feet per minute.
- Orientation relative to exterior views and other conditions.
- Access to direct/indirect sunlight as well as foot-candle requirements.
- Acoustic criteria in dBA for HVAC as well as for noise from adjacent spaces and exterior sources.
- Emissions criteria for materials selection.
- Other performance goals which should apply to the project.

5. Materials Resource Assessment. Prepare a materials resource plan that includes the following:

- Materials identified for reuse in project, for removal, and for recycling through municipal recycling programs.
- Resource efficiency/sustainability performance goals for new materials in the project.

6. Scope of Water Management Opportunities. Identify and describe in a brief narrative the overall scope of water management issues to be included in the project design. The description should encompass the following:

- Water conservation strategies and equipment.
- Strategies for the use of graywater.
- Water quality testing at the tap and at point of service.
- Collection of rainwater for irrigation, cleaning, and other non-potable uses.

45. The additional heating of the air over a city is the result of the replacement of vegetated surfaces with those composed of asphalt, concrete, rooftops and other man-made materials. These materials store much of the sun's energy, producing a dome of elevated air temperatures up to 10°F greater over a city compared to air temperatures over adjacent rural areas. This effect is called the 'urban heat island.' Light-colored rooftops and lighter colored pavement can help dissipate heat by reflecting sunlight. Tree planting can further help modify the city's temperature through shading and evapotranspiration.

7. Scope of Construction Opportunities. Identify and describe in a brief narrative the overall scope of construction issues to be included in the project's final design drawings and specifications. This description should address the following:

- *Site Protection Plan:* protection of project and adjacent properties.
- *Construction Health and Safety Plan:* protection of workers and building occupants' health relative to indoor air quality and pest control.
- *Waste Management Plan:* procedures for salvaging selected materials, recycling construction and demolition materials, and legally disposing of hazardous materials.

8. Scope of Commissioning Opportunities. Identify and describe in a brief narrative the scope of commissioning services to be performed by a separate Commissioning Agent, as well as the commissioning-related services to be performed by the Consultant. This scope description should summarize the following:

- Commissioning Agent (CA) scope of work. The CA scope includes but is not limited to developing a commissioning test plan; developing a detailed commissioning schedule; training building operators; and implementing pre-functional, functional and post-acceptance testing. It also includes developing an evaluation report, a final commissioning report, and a comprehensive Owner's Manual.
- Consultant tasks related to commissioning. These tasks include but are not limited to developing the commissioning plan outline as necessary to inform the project specifications; participating in training; and contributing to the Owner's Manual. The specifications should delineate the systems scheduled for commissioning, the nature of the tests to be performed, required attendance, and required documentation.

9. Scope of Operations and Maintenance Opportunities. Identify and describe in a brief narrative the scope of operations and maintenance issues to be included in the project. This scope description should identify:

- General client concerns and staffing limitations.
- Opportunities to support post-occupancy waste prevention and recycling activities through provision of adequate space and access requirements in the design layout.
- Opportunities to develop improved cleaning and maintenance protocols.
- Opportunities to introduce new low toxicity housekeeping materials.

Cost Estimate Deliverables

The consultant must ensure that cost consultants (or energy consultants) perform life cycle costing of discrete energy efficiency strategies (EESs). These will include alternative glazing, insulation, mechanical equipment, moisture barriers, etc. During design development, detailed, accurate information on building materials and systems, intended occupancy and use, siting, square footage, and a lot of other factors will serve as the 'raw material' for energy use modeling and analysis. The results of this process will help the design team make informed decisions regarding materials specification, space programming, and selection of EESs.

Specification Deliverables

The specifications prepared by the consultant are the key to a successful high performance project and must be prepared with particular care. They will describe any non-standard materials, construction procedures, installation methods, and other activities to ensure that the contractors will meet the overall environmental objectives of the project. Division 1 should describe any additional coordination or management activities required for the project. It should contain information on any unique material submissions and/or testing procedures required, and should provide criteria for their review. Division 1 should also contain information and resources to help contractors find non-standard materials. The flexibility of CSI Master Format and Section Format systems accommodate easy integration of added Division 1 sections or any subsequent division articles that may be required.

Owner's Manual – Outline of Requirements

The Owner's Manual ensures that the project will be maintained in accordance with design intent. For the life of the structure, the Owner's Manual serves as the primary tool for transmitting the intended architectural, mechanical, electrical, and plumbing design as conceived by the designers and realized by the contractors. Together with representatives of the client agency, these primary team members must be in agreement if the resulting building is to be comfortable and efficiently run – not just at the outset, but for the duration. In compiling the manual, each member of the project team should be identified by the consultant in the project specifications. Contributors may include the commissioning agent, consultant, construction manager, and the trade contractors. The consultant and the City should ensure collection and compilation of required material into an organized document that is then made available to the building operators.

The Manual will be organized into sections according to building systems. The consultants should provide a description of the design intent, along with performance criteria for each building system. The following information shall be included in the Manual:

1. Project Statistics. The following shall be provided:

- A complete list of the building's vital statistics, including names, addresses, and telephone numbers of all firms that have had a role in design and construction of the project.
- A copy of the building's Certificate of Occupancy.
- A copy of the final High Performance Plan.

2. Mechanical/Electrical Systems Instruction Manuals. As described by the Consultant in Section 16000 of the Project Specifications, manuals are to be provided by the trade contractors for the following systems:

- Heating Ventilating and Air Conditioning (HVAC) system.
- Hydronic distribution system.
- Air handling/distribution system.
- Glazing maintenance/cleaning.
- Kitchen HVAC system.
- Fire protection system.
- Electrical systems, fire alarm, security and UPS systems.

3. Commissioning. The following shall be provided by the commissioning agent if one is present on the project:

- A copy of Commissioning Report and a videotape of training program.

4. Operations and Maintenance. The following items shall be provided by the appropriate party:

- Specifications and maintenance protocols of lighting fixtures and lamps.
- Schedule of required building systems inspections, indicating the agency and/or vendor responsible for inspection.
- Cleaning product specifications and literature.

5. Record drawings. As-built record drawings shall be included as part of the Manual. These drawings are furnished in accordance with the *Guide for Design Consultants* at the time of Substantial Completion by each trade contractor.

6. General Requirements. Each building system shall be described in terms of major components, interconnections, operation and controls, unusual features, and safety precautions. The following data shall be included for each system:

- A detailed description of each system, showing piping, valves, and controls, illustrated by diagrams as appropriate.
- Wiring and control diagrams.
- Control sequences describing start-up, all modes of operation, and shut down procedures.
- Corrected shop drawings.
- Approved product data, including performance curves and rating data.
- Copies of certifications and test reports.
- Copies of warranties and guarantees.

The manufacturer of each component of a building system shall be identified as follows:

- Manufacturer, model number and serial number.
- Manufacturer's literature, drawings, illustrations, certified performance charts, and technical data.
- Names, addresses and telephone numbers of local repair and service companies.
- Customer service access (phone, e-mail, etc.).

Each component of a building system shall have maintenance instructions provided as follows:

- Lubrication schedule.
- Maintenance and overhaul instructions.
- Recommended spare parts list, including sources of supply.
- Name, address, and 24-hour telephone number of each subcontractor that installed the system or equipment.

7. Checklist. The consultant shall provide a Checklist for trade contractors' use in compiling the documentation required for each system included in the Manual. The Checklist will include items such as operating and maintenance manuals, and any warranties or guarantees that the Contractor is required to submit.

Summary Table of High Performance Key Submittals and Deliverables

	Pre-Preliminary: Develop High Performance Plan*	**Schematic Design Phase**	**Design Development Phase**	**Construction Documents Phase**	**Construction Phase**	**Occupancy Phase:** Owner's Manual*
Design Process	**Implementation Strategy (1)***					
Site Design and Planning	**Site Opportunities (2)***		*Specification citing native species, optimal planting schedules*	*Tree pit size and mass transit/bicycle amenities confirmed*		**Sustainable landscaping, pest management plans***
Building Energy Use	**Operating Energy Analysis (3)***	**(Computer) model the envelope, siting, and HVAC plant options***	**Further modeling of HVAC/ lighting options***	*Refine calculations based on design development*		**Maintenance and system descriptions***
Indoor Environment	**Environmental Program Matrix (4)***		*Update environmental programming matrix*	*Confirm conformance of design to matrix recommendations*		**Maintenance and system descriptions***
Materials and Products	**Materials Resource Assessment (5)***		*Environmental criteria included in outline specification*	*Environmental criteria included in final specifications*	*Review material certifications and MSDS sheets*	**Material certifications and MSDS sheets***
Water Mangement	**Scope of Water Management (6)***		*Review test data for equipment and components*		**Lab results at water service***	**Lab results***
Construction Administration	**Construction Scope of Construction Opportunities (7)***			**Site protection, health, safety and waste plans***	*Review submission of site, health & safety and waste plans*	
Commissioning	**Scope of Commissioning Opportunities (8)***			**Commissioning plan and specifications***	**Scheduling, testing, and evaluation report***	**Training tape, commissioning final report***
Operations and Mainteneance	**Operational Waste Analysis (9)***		*Recommended waste prevention and recycling measures*	*Design review of materials and details for maintenance*		**Maintenance and cleaning protocols***

* Items in bold indicate deliverables to be submitted by the consultant apart from typical project deliverables as described in the *Guide for Design Consultants.*

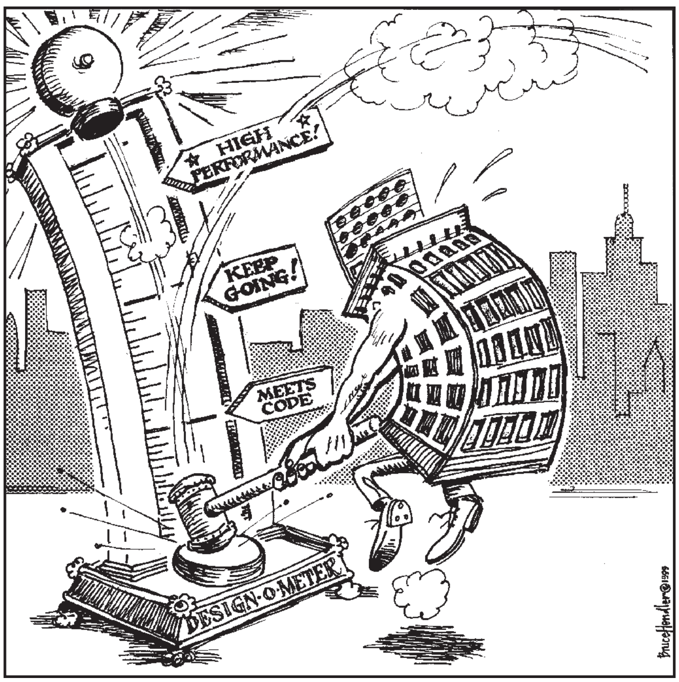


Illustration: Bruce Hendler

Design
Process

Part Three: Technical

Site Design and Planning

Preservation of site resources and conservation of energy and materials – both during construction and in ongoing building operations – are important and often overlooked benefits of good site design. Sustainable site planning identifies ecological, infrastructural, and cultural characteristics of the site to assist designers in their efforts to integrate the building and the site. The intent is to encourage optimum use of natural/existing features in architectural and site design, such that building energy use is diminished and environmental degradation is minimized.

Site Design and Planning

Understanding the Site

Benefits ◀

$\$C_F$

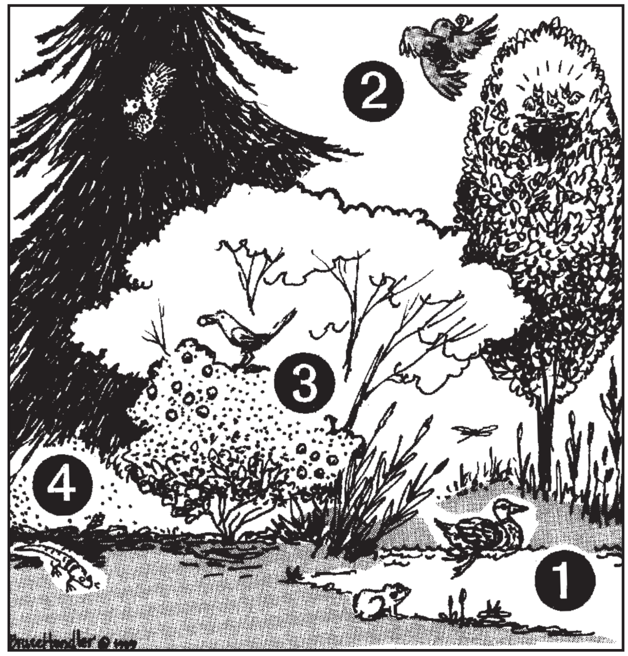
$\$C_M$
Proper assessment of site resources can eliminate unnecessary infrastructure and facilities expenditure.

E_S
Protection of local ecology.

Inventory and analyze site resources, relationships, and constraints to better enable the designers to maximize energy efficiency while conserving and restoring ecological and cultural resources.

Technical Strategies

❑ **Inventory and analyze the regional and local ecological context**. This will allow the design team to better understand and respond to site conditions, opportunities and constraints. Inventory and analysis includes, but is not limited to:
- Relevant climate-specific characteristics.
- Existing air quality and ground level wind patterns.
- Soil and ground water testing to determine pollution levels, water table, bearing capacity, and what types of fertilizer or soil amendments may be necessary for planting. Determine the need for retaining/stockpiling existing topsoil.
- Inventory of existing vegetation and ecologically sensitive areas, and identification of any threatened species or significant habitats.
- Mapping of natural hazard zones, such as exposure to high winds and storms, floods, unstable soils, steep slopes, fault lines, former (buried) water features, etc.



Inventory of Existing Vegetation and Ecologically Sensitive Areas
An inventory of a site's plant species – and an understanding of the ecological niche into which they fit – will reveal which areas are either sensitive or threatened, and which serve as wildlife habitat. The image above illustrates some of the relationships between vegetation and a site which either establish or enhance wildlife habitat: ❶ surface water; ❷ a variety of tree canopy heights; ❸ fruit-bearing "native" plant species; and ❹ natural leaf mulch.
Illustration: Bruce Hendler

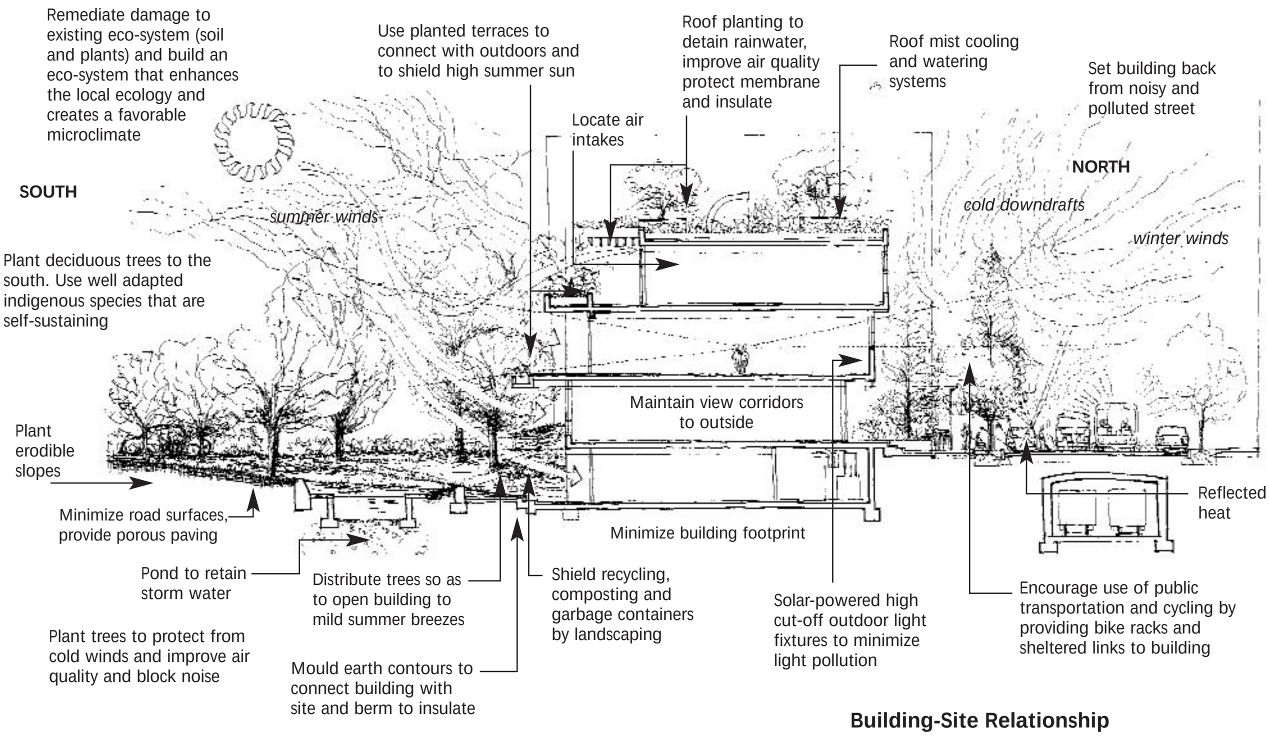
❑ **Topographical features**. Survey topography, existing plants, and water features to better understand grading and drainage issues.

❑ **Inventory and analyze urban/historical context** and community resources in order to effectively respond to cultural issues.
- ❍ Inventory infrastructure and utilities.
- ❍ Analyze transportation system and existing/potential linkages to the site.
- ❍ Identify construction constraints.
- ❍ Review land use patterns in the immediate area.
- ❍ Review the site's cultural resources for possible restoration or incorporation.
- ❍ Examine the architectural style(s) present in the neighborhood and consider the use of historical styles or traditional materials as a means of integrating the new or renovated building with the surrounding area.
- ❍ Analyze cultural features and activities in the neighborhood and identify possible connections to the project.

❑ **Identify and prioritize the site's natural and cultural attributes** that are to be protected, conserved, or restored.

Building-Site Relationship

Taken together, the site design and building design should support the ecological and cultural functions of the entire development. Well-designed open space creates a sustainable microclimate that in turn reduces building energy use and supports a high-quality interior environment. The project as a whole should be designed to minimize negative environmental impacts on surrounding areas and to maximize opportunities to restore natural systems.



Building-Site Relationship
Illustration: Johannes Knesl

Steinhardt Conservatory
At the Steinhardt Conservatory located in Brooklyn Botanical Gardens, new buildings are situated and formed to fit well in the existing sloped landscape, creating and reinforcing the relationship between an outdoor cafe and windows that look in on interior plantings.

▶ **Benefits**

$\$O_F$, C_F
Integrated site/building design promotes operating savings and can reduce construction costs.

$\$P_F$
Improved occupant satisfaction through landscaping and views.

E_S
Improved building and site microclimate reduces urban heat island effect.

E_S
Green buildings are good neighbors, reducing negative climate and other environmental impacts, and setting the local standard for performance.

Technical Strategies

❑ **General Site Layout**

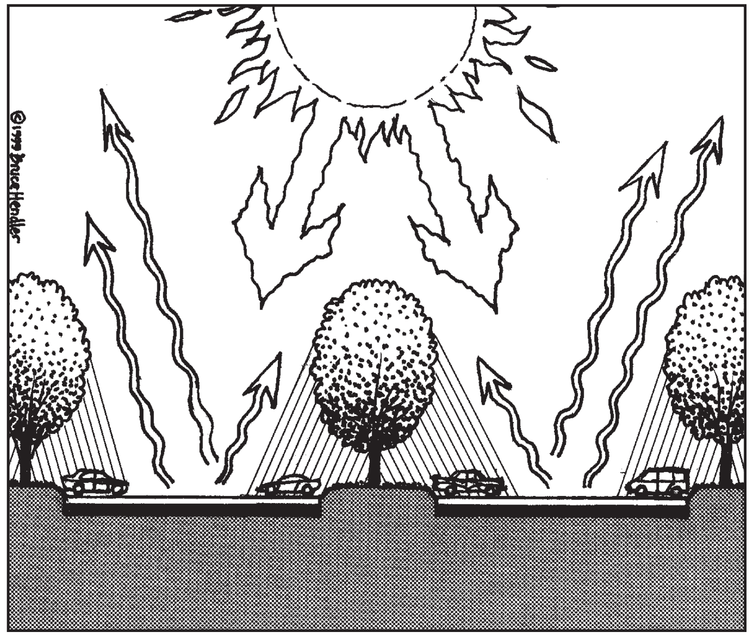
- ❍ Organize building mass, orientation and outdoor spaces to provide efficient access to services; incorporate recreational areas that have multiple functions in addition to visual value. For example, rooftops can be used as gardens and for water collection; a water feature in a playground can provide both cooling and recreation for children.
- ❍ Use earthforms, plantings, drainage and water detention systems, and soils to support the functions of the building and site (e.g., screening, windbreaks, etc.).
- ❍ Employ passive solar principles in architectural design, orientation, and siting; use heat-retaining courtyard pavements (with proper shading), block winter wind and admit summer breezes.
- ❍ Map sun and shade patterns associated with new construction. Design landscaping that optimizes selection and positioning of plants for sun and shade.
- ❍ Incorporate adequate space for operational recycling and maintenance, including space for collection, storage, and access for collection vehicles.

❑ **Improved Environmental Quality**

- ❍ Coordinate landscape design with building envelope design. Orient building, windows, and outdoor spaces to work together, taking advantage of light, air flows, and interesting views. For example, use plant materials to screen parking and service areas, or orient a conference room window toward a pleasant view. Design landscaping to be seen from and complement interior spaces. Capitalize on views into and out of the site and adjacent areas.
- ❍ Use deciduous shade trees and exterior structures such as louvers, arbors, and trellises to reduce cooling loads within the building.

❑ **Mitigation of Negative Impacts**

- ❍ Reduce the urban heat island effect through tree planting and pavement selection strategies. In parking areas, use planting strips between sections of pavement to screen cars, reduce vast expanses of asphalt, and separate pedestrians from traffic and service areas. Consider planting trees and other vegetation along the perimeter or, if possible, within the parking area itself. Specify light colored paving with an albedo reflectance of at least 0.5; consider the use of porous pavement.
- ❍ Design to reduce potentially detrimental conditions, such as erodible slopes, slippery soils, high water table, and undue exposure to storms.



Mitigation of Urban Heat Island Effect
Illustration: Bruce Hendler

- ❍ Avoid adverse impacts on adjacent properties, such as reflected glare and light at night, shading of adjacent greenspace, noise, air pollution, waste heat, or creation of gusty winds at grade.
- ❍ Select light fixtures that reduce or eliminate the effects of light pollution on neighboring sites and the sky.

❑ **Site Lighting**

- ❍ Use light colored or reflective edges along driveways or walks to reduce dependence on high-wattage electrical lighting at night. Use high-efficiency lights in exterior contexts such as uplighting fountains or sculptures, parking lights, and pedestrian lights.
- ❍ Use solar power for exterior lights, telephones, and fountain pumps whenever site conditions allow.

Prospect Park Swan Lake and Ravine Stream
In this innovative project, a lake and stream system was designed to conduct water through the site, and to provide water storage and a sediment settling basin as a natural means of storm water control.

Beach Channel Drive Child Care Center
This child care center (currently under construction in Queens, New York), features a roof-top playground with both sunny areas for play and shaded quiet areas. The roof bulkhead elements are designed with colorful metal roofing. The facility also has plantings on the roof and trees around the perimeter.

Sustainable Landscape Practice

The landscape features must be selected and configured to suit site conditions and restore habitat using self-sustaining landscape design and site maintenance procedures. Practices should promote the conservation and restoration of existing biological and water resources, including species diversity, soil fertility, and aeration.

Historic Richmond Town
At Historic Richmond Town, Staten Island, the cultural institution's master plan for restoration and development calls for the preservation and enrichment of existing wetlands and water's edge plant communities, and for the remediation and restoration of wetlands that have been disturbed.

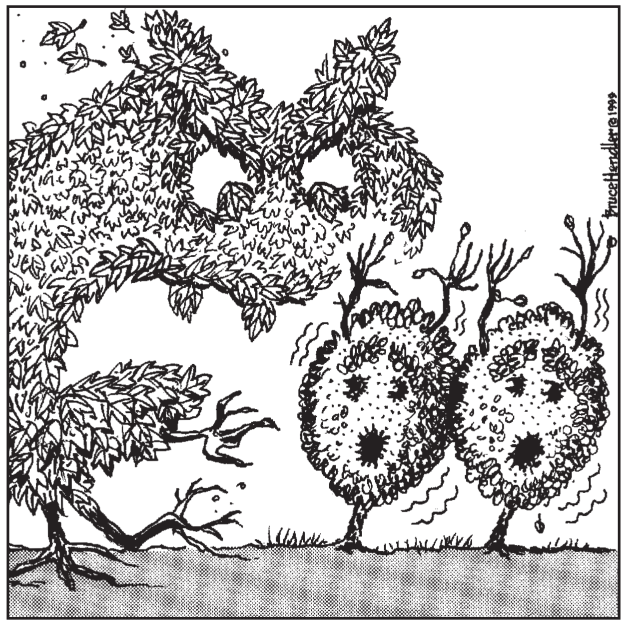
▶ **Benefits**

$\$0_F$
Reduced landscape and hardscape maintenance costs.

$\$0_M$
Water harvesting/ reuse practices reduce burden on City water management systems.

Technical Strategies

- **Planning Practices**
  - Reduce reliance on plant species that require frequent irrigation and maintenance. If irrigation is necessary, consider drip irrigation and other water-efficient irrigation systems. Emphasize plant diversity, plants that are native to the region and microclimate, and those which naturally grow together and are self-sustaining (i.e. reseed and spread without much maintenance).
  - Where planting adjacent to building openings such as air intakes, entries, or operable windows, avoid allergy-causing plantings and those requiring chemical treatment.
  - Avoid invasive species (those which threaten local native ecosystems).[46]
  - Reduce dependence on fertilizer by using plants that contribute nitrogen to the soil (clover, honey locusts, black locusts, and other legumes).



Invasive Species
Illustration: Bruce Hendler

  - Provide good growing conditions, including adequate root space for plants, and especially for street trees. Tree pits should be 3-5 times the size of root ball dimensions. Wherever possible, locate trees so that the rooting zones of more than one tree can be combined.
- **Water Use/Pollution Prevention**
  - Prevent non-point source pollution by planting watershed buffers, allowing infiltration via porous surfaces, and minimizing parking. Porous surfaces include materials such as gravel, sand, 'grasscrete,' and 'geoblock.'
  - Remediate water quality by filtering stormwater through plantings and soil, preventing erosion, and buffering bodies of water from pollution sources. In some areas of the City, this will also reduce loads on combined storm and sewer lines.
  - Harvest rainwater and stormwater for irrigation and other uses on site, and to recharge the aquifer.
  - Reduce water pollution from pesticides, herbicides, and fertilizers by using plant combinations and maintenance methods that do not require chemicals.[47]

46. While not an all-inclusive listing, the major plants of concern are as follows: Norway Maple, Sycamore Maple, Japanese Honeysuckle, Russian Olive, Rugosa Rose, Multiflora Rose, Oriental Bittersweet, Amur Cork Tree, Ailanthus, Japanese Barberry, Porcelainberry, Privet, and Purple Loosestrife.
47. Plants that have few pests, or 'companion' planting. Use salt for melting ice.

- ❑ **Soil Quality**
  - ❍ Analyze planting soil and implement on-site soil remediation measures such as introducing earthworms if they are sparse, adding organic matter and microorganisms to break down pollutants, and removing toxic materials.
  - ❍ Use mulch to conserve soil moisture, restore soil fertility, and reduce the need for fertilizers. Leave grass clippings, small plant debris, and fallen leaves to decompose on the ground. Use compost for soil amendment in lieu of peat moss (a non-renewable resource).
  - ❍ Provide space and bins for composting of landscape materials.
- ❑ **Resource Use**
  - ❍ Use recycled, renewable, and locally available materials when constructing landscape features (e.g., recycled timber, plastic, rubber tires).
  - ❍ When available, obtain compost from New York City facilities.[48]

Encouraging Alternative Transportation

Benefits ◄

E_S Reduced vehicular pollution.

The site should offer support facilities for bicycling, mass transit, electric vehicles, carpooling, and other less-polluting means of transportation.

Queens Atrium Corporate Center
The Queens Atrium Corporate Center (formerly the International Design Center of New York, Center # 2), Long Island City, provides a shuttle bus to and from mass transit and a covered shelter. The site also has a bicycle rack. This building is now the home of the Department of Design and Construction.

Technical Strategies

- ❑ **Provide adequate bicycle amenities**. Include features such as secure interior and/or exterior storage, lockers, and shower facilities.
- ❑ **Bus stop seating areas.** Provide covered, wind-sheltered bus stop seating areas or waiting areas within enclosed building lobby, as applicable.
- ❑ **Provide alternative fueling facilities.** Consider ethanol, a natural gas pumping station, and an electric car battery charging site.
- ❑ **Carpool incentives.** Provide a preferred carpool parking area.

48. Call the Sanitation Action Center at 212-219-8090 for information on compost availability.

Building Integration

Building Energy Use. Exterior lighting design and the various types of light sources (i.e. mercury vapor vs. sodium vapor) will have an impact on the health and growth of plant life. Tree planting schemes will have a growing impact on daylighting, shading, and other passive solar opportunities.

Water Management. Plumbing design should incorporate site design elements that support stormwater and graywater management.

Operating and Maintenance Considerations. Site design must incorporate adequate space for operational recycling and maintenance.

PERFORMANCE GOALS: NEW CONSTRUCTION AND RENOVATION

Site Design and Planning

- ❑ Identify and mitigate all existing site problems including contamination of soil, water, and air, as well as any negative impacts caused by noise, eyesores, or lack of vegetation.
- ❑ Every outdoor space shall have two or three functional uses.
- ❑ Demonstrate that the new building will minimize negative impacts on neighboring properties and structures; avoid or mitigate excessive noise, light pollution, shading on green spaces, additional traffic, obscuring significant views, etc.
- ❑ Plantings shall be comprised of: least 50% species native to the New York City area; and 75% low-maintenance (i.e., requiring minimal mowing, weeding, and trimming). The planting scheme shall incorporate biodiversity.
- ❑ For buildings exceeding a 10-minute walk from mass transit, provide secure bicycle parking spaces for 5% of building occupants, and an appropriate number of showers. For a building located closer to mass transit, provide secure bicycle parking spaces and showers for a minimum of 2% occupancy.
- ❑ Design and construct a development (including building, utilities, access, and parking) that exceeds by 25% the open space requirement for the site based on local zoning.
- ❑ Specify high-albedo (light colored) materials for 80% of paved surfaces.
- ❑ Plant at least one tree on the site for every 1,000 square feet of impermeable surface. Tree pits dug in pavement should be a minimum of five feet by five feet.
- ❑ When compatible with local zoning, consultant shall demonstrate that the development:
  (1) permits the highest possible square footage of green open space in relation to the building's footprint; and
  (2) permits the highest possible square footage of the building's surfaces to be dedicated to green space.

Deliverables:

Pre-Preliminary. The Site Opportunities section of the High Performance Plan shall include:

- ❍ Analysis of bio-climate, including solar access diagrams, prevailing wind analysis, and identification of appropriate means for deploying passive solar and natural ventilation strategies.
- ❍ Analysis of existing and potential topographical and landscaping features that can contribute to reductions in energy use.
- ❍ Analysis of existing site characteristics such as views, adjacent open spaces and environmentally sensitive areas, vegetation, seasonal flooding, exposure to seasonal storms and high winds, and wildlife habitat. Identification of appropriate responses to identified conditions.
- ❍ Analysis of opportunities to mitigate urban heat island effect and urban light pollution.
- ❍ Analyses of urban/historical/cultural context, community resources, land use patterns, and architectural styles. Identification of project attributes that should be protected, conserved, or restored.
- ❍ Analysis of subgrade characteristics and suitability for plant life. Analysis of suitability for geothermal applications.
- ❍ Analysis of mass transit/bicycle site access and opportunities to encourage same.

Design Development. Site Report shall include:

- ❍ Plant list.
- ❍ Specification language indicating that restoration of the natural systems subsequent to construction disturbance has been maximized by scheduling planting in late spring or early winter, optimum seasons for most species. (On sensitive sites, if wildlife habitats are present, schedule construction so as to not interrupt nesting.)

Construction Documents. The Builder's Pavement Plan and/or site plan shall indicate:

- ❍ Location and size of optimized tree pits.
- ❍ Bicycle access, parking, and storage.
- ❍ Mass transit-related amenities (sheltered/covered bus stops, seating, waiting areas).

Operations. The Owner's Manual shall include:

- ❍ Descriptions of sustainable landscape maintenance practices.
- ❍ An integrated pest management plan for the site.

Regulatory Issues

- ➠ Care must be taken in site detailing to coordinate with the New York City Landmarks Preservation Commission/Historic District restrictions.
- ➠ Review the health regulations related to water reuse restrictions.
- ➠ Coordinate with the Department of Transportation (DOT) and Department of Parks and Recreation (DPR) for street trees: regulations related to species, location(s), and tree pit design/planting.

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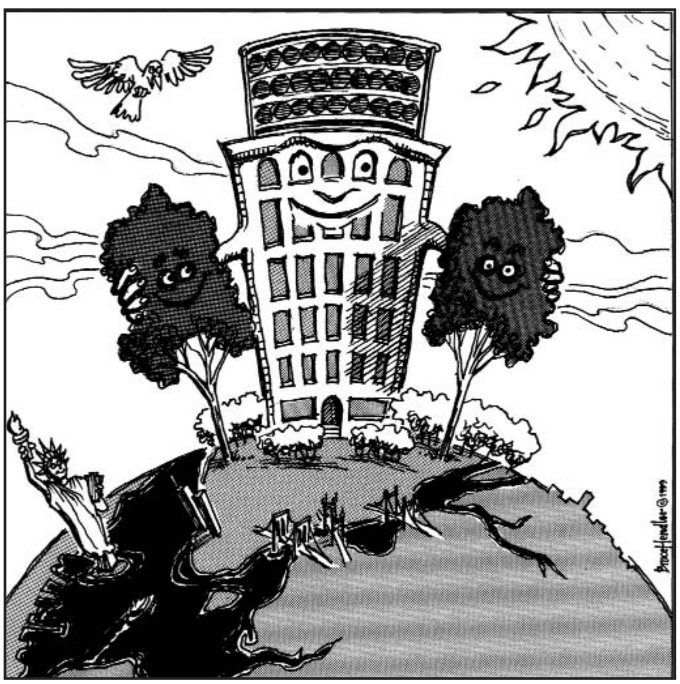


Illustration: Bruce Hendler

Building Energy Use

Today's world view of energy efficiency is very different from the energy conservation mentality of the 1970s, which is recalled by those of us who were around then as a time of long lines at the gas pumps and diminished comfort in our homes and places of work. The energy efficiency model of today involves benefits, not sacrifices. In high performance buildings, energy efficient design begins with a methodical reduction of the building's heating and cooling loads – those imposed by climate and those generated by people and equipment. With all loads minimized, mechanical systems are then selected based on highest output for lowest fuel consumption. The new efficiency means optimizing the performance of each of the building's components and systems both individually and in interaction with other energy-consuming systems – air conditioning, lighting, domestic hot water, etc. This is known as the practice of 'design integration.' In tandem with other energy efficient practices, building systems integration can provide excellent returns on the initial investment. Current practice also embraces the use of renewable energy technologies that reduce our reliance on fossil fuels and help alleviate carbon dioxide and other greenhouse gas emissions.

Computer software with proven reliability is now available that will predict energy costs for a proposed building design. This energy software, which is essential in the analysis of energy efficiency measures, facilitates informed decision making through the course of the design process. More specialized software, which describes specific environmental features such as daylight distribution and air flow patterns, is also useful for the successful integration of design quality with energy reduction.

Building Energy Use

Site and Massing Considerations

Benefits ◀

$\$O_F$
Diminished heating and cooling loads reduce operating energy costs.

$\$C_F$
Together with other passive solar and integrated design strategies, site selection, configuration, and building orientation can significantly reduce the size and cost of mechanical systems.

Taking advantage of the physical features of the building site and microclimate will reduce heating and cooling loads, thereby lowering overall energy consumption.

Technical Strategies

- ❑ **Solar access.** Orient the building to maximize solar opportunities.
- ❑ **Prevailing winds.** Orient the building to minimize thermal loss due to infiltration from prevailing winds while taking advantage of natural ventilation.
- ❑ **Tree location.** Carefully consider the placement of existing and proposed deciduous and evergreen trees on site. When practicable, locate so that deciduous trees block summer sun to the south and west of the building and evergreens block winter wind on the north face of the building.
- ❑ **Topographic modifications.** Utilize or modify existing topography to optimize thermal mass and/or insulation. Consider earth forms, berming, and other manipulations of the site section.

Interior Layout/Spatial Design

Benefits ◀

$\$O_F$
Diminished heating and cooling loads reduce operating energy costs.

$\$C_F$
A well-designed layout can contribute to reductions in the size and cost of mechanical systems.

An appropriate layout of program spaces will help reduce energy consumption and will promote the use of passive solar heating and cooling.

Technical Strategies

- ❑ **Program zoning.** Group similar program functions in order to concentrate similar heating/cooling demands and simplify HVAC zoning loads. Determine optimum locations within the building so as to take advantage of microclimate conditions and building orientation.
- ❑ **Non-windowed spaces as buffers.** When using passive solar design for heating, non-windowed spaces should be located on the north side against the exterior wall to create a thermal buffer for the main functions on south side.
- ❑ **Circulation zones as buffers.** Design public areas and circulation zones to serve as thermal collectors and buffers. These spaces can accept a wider range of temperature swings, based on limited duration of occupancy.
- ❑ **Layout for natural systems.** Whenever possible, configure occupied spaces to optimize natural ventilation and daylighting. In general, locate open occupied spaces adjacent to exterior windows and use borrowed light for interior offices. Specify low partitions in office areas adjacent to window walls to enhance penetration of daylight to interior.
- ❑ **Existing natural systems.** In an existing building, reuse and enhance existing built-in passive solar and energy efficiency strategies (EESs) such as natural convection, air circulation, building mass as a thermal flywheel, natural daylighting techniques, and other means.
- ❑ **Stairs.** Provide inviting, pleasant staircases to encourage the use of stairs rather than elevators in low-rise buildings.

Passive Solar Design Strategies
The Knapp Street Laboratory and Visitor's Center is a 31,000 sq. ft. low-occupancy building that was designed to utilize winter solar gain to reduce demand on heating and lighting systems. To achieve this, support spaces, including mechanical, storage, and lavatories, were located on the north side of the building with minimal fenestration. Occupant spaces were concentrated on the south side, accompanied by large amounts of fenestration. Because of the seasonal variation in sun elevation, this approach provides deep solar penetration in winter and a minimal amount of solar penetration in summer.

Building Envelope

Appropriate assembly of wall, roof, foundation, and window materials will provide good thermal and moisture control, while supporting reductions in building energy use. A good envelope harnesses natural energy through effective use of passive solar and daylighting techniques.

▶ **Benefits**

$\$O_F$
Diminished heating, cooling, and lighting loads reduce operating energy costs.

$\$C_F$
A well-designed envelope can substantially reduce the size and cost of mechanical systems.

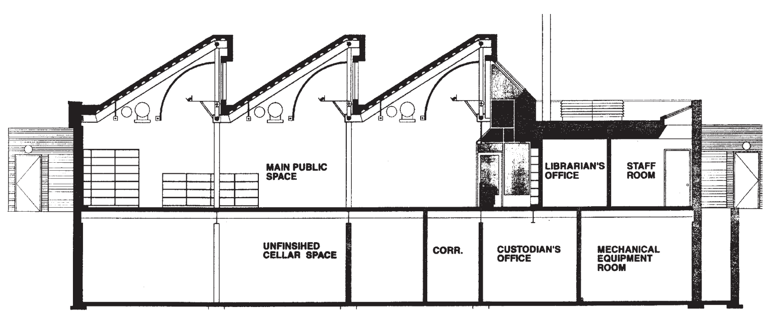
The New Children's Center
The foster care intake/training facility for the Administration for Children's Services is being retrofitted into a historically significant structure that was built in 1912. For comfort as well as energy savings, the envelope is being upgraded with additional insulation (cellulose) and detailed to prevent thermal bridging. It also utilizes new higher performance windows.
Richard Dattner Architect, P.C.

Technical Strategies

❑ **Passive solar (whole building) design strategies.** Use passive solar, 'whole building' design techniques and simple, effective technologies to achieve low- or no-cost heating, cooling and daylighting. Strategies and techniques may include:

- Regulation of solar impact through appropriate fenestration and shading devices. A common and highly effective approach is to specify glazing with low emissivity (low-e) coatings and high R-values to reduce solar heat gain/loss. Shading strategies, such as vertical fins on east and west fenestrations, overhangs on the south side, arcades, trees, brise-soleils, and deep window insets, are also effective components of passive solar design.
- Moderation of interior temperature extremes through the use of thermal mass where appropriate. A building's thermal mass resides in materials such as masonry and concrete that have the capacity to store and release heat as interior and exterior temperatures fluctuate. Building mass can function as a kind of thermal flywheel, in that it moderates the extremes of thermal loading within a building.
- Enhanced insulation in the building shell to reduce energy loads.[49]
- 'Air-lock' entrances to reduce heat loss or gain.
- Light-colored, reflective roof surfaces to reduce cooling loads and diminish the urban heat island effect. (See page 48)

❑ **Natural ventilation.** Consider integrating natural ventilation strategies in the design of HVAC and exterior wall openings to reduce reliance on mechanical ventilation during swing seasons.



New South Jamaica Branch Library
Given the siting constraints of this new branch library, the roof is the primary envelope element available as an interface with the natural environment. The south-facing monitors introduce sunlight for direct heat gain during the winter and lighting year-round. During the cooling seasons, automated shades limit the light to just the levels needed for library functions. The peaks in the roof collect the hotter air, which during the winter is circulated through the building by the HVAC system. During the cooling seasons, this hot air is exhausted. Curved diffusing baffles and reflective light shelves prevent direct sunlight from reaching the occupied areas of the building. The light fixtures are controlled by photo-sensors, filling in whatever portion of the required levels are unmet by daylight.
Stein White Architects, LLC

49. Typical payback analyses based on current fuel prices may not justify expense. However, as fuel prices will be rising, the cost of future retrofit for insulation may cost many times the minimal expense of initial high R-value installation.

- ❑ **Envelope detailing.** To prevent moisture build-up within the walls, detail the material assembly of the envelope in accordance with best vapor barrier practices. Use monolithic building systems and assemblies as opposed to smaller assembly parts. This will minimize the need for caulking and weather-stripping and will significantly reduce infiltration. Avoid thermal bridging through the exterior walls, roof, and floor details and components.
- ❑ **Reduction of convective heat losses from unplanned air flows.** To reduce stack effect, seal between floors, stairwells, corridors, and elevator shafts. Be sure to seal distribution plenums and ductwork. Plan air pressure relationships between rooms as necessary.
- ❑ **Radiant cooling.** Radiant cooling techniques may be worth investigating for internally load-dominated buildings. This technique utilizes the building envelope as a heat sink for the interior.

Daylighting / Sun Control

Benefits ◀

$\$O_F$ Diminished heating and cooling loads reduce operating energy costs.

$\$C_F$ A well-designed envelope provides sun control and reduces the size and cost of mechanical systems.

$\$D_S$ Improves market for high performance glazing and other sustainable building envelope materials.

$\$A_S$ Significantly lowers electrical use, reducing pollution emissions at power plants.

Whenever possible, controlled daylighting should be incorporated into the building as the preferred mode of interior illumination and to reduce lighting load and operating costs. This saves the most expensive form of energy we use: electricity, and the charges associated with peak demand.

Technical Strategies

- ❑ **Glazing.** Specify glazing with high visible transmittance and integrate placement in building envelope to control glare. Consider the use of glass with higher daylight transmittance and lower shading coefficients on north walls where glare is much less of a problem. Consider fritted, translucent, and spectrally selective glazing tuned to end use and orientation.
- ❑ **Monitors and clerestories.** Consider the use of roof monitors and high clerestory windows in addition to or in place of skylights. If using skylights, consider models that respond to differences in seasonal sun altitudes.
- ❑ **Dimmers.** Specify and coordinate placement of photocell-dimming sensors that adjust electric lighting in response to the amount of available natural light.
- ❑ **Light shelves.** Consider the use of interior and/or exterior light shelves on south-, east- and west-facing facades to reflect natural light deeper into interior spaces. Provide shading devices, such as overhangs or vertical fins, to let in quality natural light but exclude undesired glare while controlling contrast ratios.
- ❑ **Courtyards and atriums**. Incorporate courtyard, atrium, or other daylight-enhancing techniques to bring light into the interior.
- ❑ **Fiber-optics.** For special applications, consider fiber-optic technologies or light pipes that transmit natural light deep into interior spaces.

Light Pollution

Benefits ◀

$\$O_F$ Reduces energy demand for night lighting.

E_S Reduces negative impact on urban ecology.

Sensitive site lighting will reduce light pollution[50] in the sky, between buildings, and in open spaces, thus avoiding negative impacts on plants, animals, and people. Good lighting design also reduces energy waste while improving night views of the sky.

Technical Strategies

- ❑ **Reduced night lighting needs.** Reduce security lighting required for open spaces by securing off-limits areas and/or installing motion sensors. Limit lighting to zones where it is necessary for safe passage to entry and exit areas; control by timers. In other areas, provide security lighting controlled by motion sensors.
- ❑ **Proper cut-off angles.** Use outdoor lighting fixtures with cut-off angles that prevent light from going upward or too far beyond the intended area of illumination.
- ❑ **Lighting fixture height.** Reduce the height of luminaires relative to property boundaries. This will prevent light from straying onto adjoining properties.

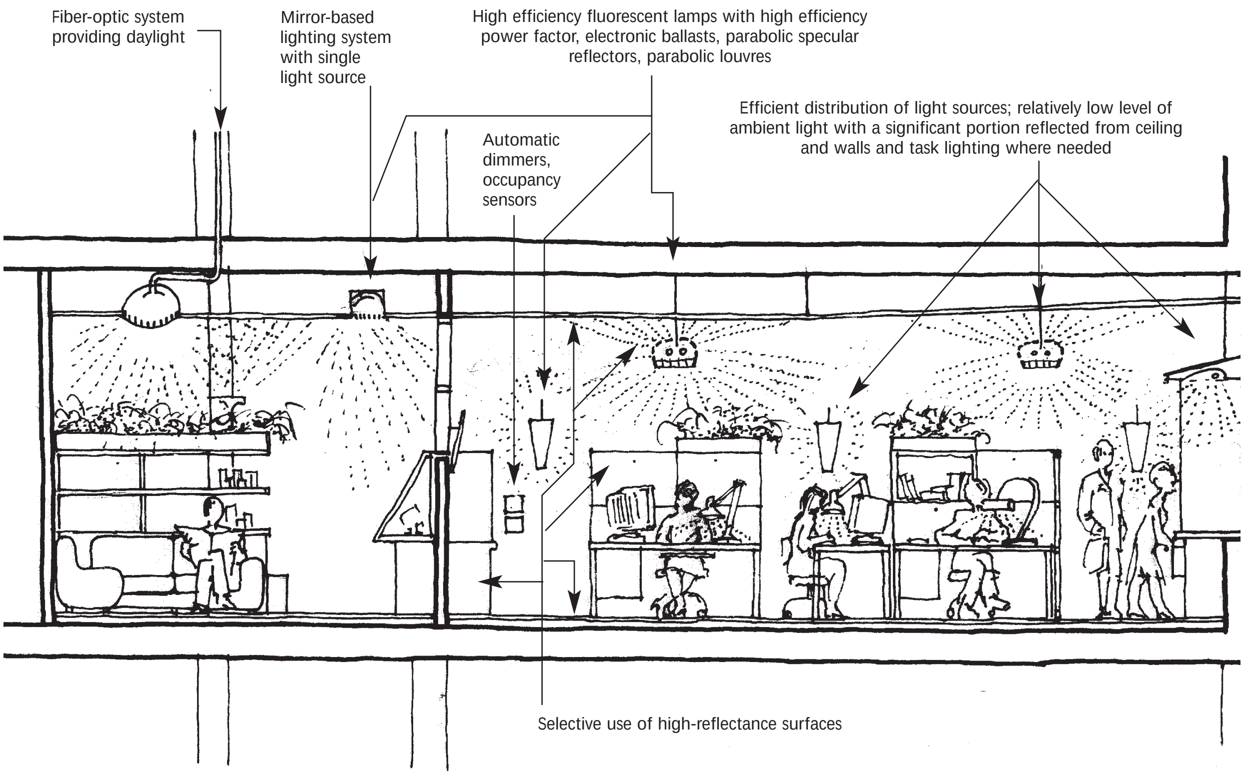
50. Light pollution – excess brightness in the sky resulting from direct and indirect lighting above urban areas – has had a negative impact on the urban ecology, disrupting biological cycles in plants and animals. It has also been hypothesized that human health requires a certain amount of exposure to darkness. The amount of energy wasted in lighting the sky or outdoor and indoor spaces that do not need it, has been estimated conservatively at approximately $2 billion per year in the US. (Environmental Building News, Vol. 7, No. 8, P.11).

High Performance Lighting

"Because lighting systems are major energy users, they can yield high returns through improvements in efficiency."

Adrian Tuluca,
Steven Winter Associates

A highly efficient light level distribution that improves visual quality while reducing electrical use may be achieved through efficient lighting layout, lamps, luminaires, and other components, together with localized lighting controls. Use fixtures that minimize the use of hazardous lamp materials.



High Performance Lighting
Illustration: Johannes Knesl

Technical Strategies

- ❑ **Lighting power density.** Minimize lighting power density to meet project requirements by designing a lighting system with characteristics such as:
  - ❍ Efficient light source distribution. Make the most of illumination source output by designing for appropriate room geometry, room surfaces (high surface reflectance), mounting heights, and use of parabolic specular reflectors and deep parabolic louvers.
  - ❍ Low ambient lighting levels with task lighting, where appropriate. Consider lighting fixtures that provide significant illumination of ceilings and walls. These include pendant fluorescent lighting fixtures that direct light up and down.
  - ❍ High efficiency lamps and luminaires with electronic ballasts. These have a low propensity to attract dirt deposits, incorporate a minimum of hazardous substances, and are well cooled for optimum performance.
  - ❍ Efficiency-based controls, such as dimmers, occupancy sensors, photo cells, and time clocks.
  - ❍ Lumen maintenance controls. Since lamp efficiency degrades over time, the designer often compensates by 'overdesigning' the lighting system to account for reduced lumen output later on. Where appropriate, install lumen maintenance controls to ensure that no more than the required footcandle levels are delivered to the space. This will save energy in the early stages of the lamp's life.
- ❑ **Fixture uniformity.** Achieve and maintain uniform lumen levels through group relamping. This also allows for designing to a lower installed wattage.

▶ **Benefits**

$\$O_F$
Diminished cooling loads help reduce operating energy costs.

$\$C_F$
Reduced heat energy from lighting lowers the size and cost of the building's cooling system.

$\$C_F$
Increased first-cost for high efficiency lighting systems and additional task lighting is often offset by operating energy cost savings.

$\$A_S$
Significantly reduced electrical use limits greenhouse gases and other emissions at power plants.

Building Energy Use

High Performance Lighting
A typical high performance office environment may offer an ambient light level of 30 foot candles, supplemented by task lighting. High efficiency fluorescent lamps with parabolic reflectors and deep louvers could be used to achieve this level of illumination, providing a distribution of approximately 80% down and 20% up to the ceiling. High efficiency tri-phospher lamps would be selected for their capacity to provide as near a full daylight spectrum as possible; dimmer switches and occupancy sensors would then be used with automatic controls to adjust lighting levels as needed.

Blue Cross/Blue Shield Building
At this new building in Rochester, New York, a combination of indirect fluorescent lighting (with dimmable electronic ballasts), task lighting, and lightshelves for daylighting was used. Here, an already well-designed lighting scheme was improved to reduce lighting usage by an additional 13%, reduce the perimeter lighting use by 35%, and resulted in a net savings of $11,400 per year. The lightshelves helped convey ambient daylight deep into the workspace.

Electrical Systems and Equipment

Benefits

$\$O_F$
Efficient electro-technologies help lower operating energy costs (motors, fans, other equipment).

$\$C_F$
Reduced heat energy from electrical equipment can lower cooling system costs.

$\$A_S$
Efficient electro-technologies and equipment lowers electrical use, which in turn reduces power plant emissions.

Efficient design strategies, power distribution systems, and electrical equipment can increase building's energy efficiency and reduce energy consumption and associated costs.

Technical Strategies

- ❑ **Cost comparison.** In large buildings, analyze and compare the costs of distributing power at 208/120 volts and 480/277 volts, if services are available.
- ❑ **Equipment specification.** Specify energy efficient office equipment, including computers, printers, and copy machines. Select equipment with the Energy Star label. For computers, consider liquid crystal display screens in lieu of conventional monitors.
- ❑ **Distortion minimization.** Minimize the distortion effects of non-linear loads (personal computers, etc.) on the power distribution system by using harmonic filters.
- ❑ **Power factor.** Improve the power factor by specifying appropriate equipment as required.
- ❑ **Transformers.** Use K-Rated transformers to serve non-linear equipment.
- ❑ **Efficient motors.** To reduce energy use, consider premium efficiency motors, controls, and variable frequency drives for motors greater than one horsepower.
- ❑ **Direct current utilization.** Utilize direct current (DC) from the photovoltaic system, fuel cell, or other source in lieu of conversion to alternating current (AC). DC may be appropriate for certain applications such as discrete lighting circuits or computer equipment.
- ❑ **Avoid electromagnetic pollution/exposure.** Locate high concentrations of electricity (such as panelboards, transformers, or motors) away from building occupants/personnel. If necessary, install electromagnetic field (EMF) shielding.
- ❑ **Videoconferencing.** Consider application of videoconferencing between agencies to eliminate energy/emission costs and productivity losses caused by transportation to and from meetings.

Energy Sources

Various energy sources are available today. Designers should first capitalize on conservation techniques, *then* work to achieve an appropriate, integrated balance of solar heating, daylighting, energy entrained within the earth (geothermal energy), air movement, and other renewable resources. Only then should they resort to fossil fuel technologies, seeking efficiencies in this realm as well. This integrated approach to whole building design reduces the production of greenhouse gases, smog, and acid rain; preserves natural resources; and slows the depletion of fossil fuel reserves. Energy sources are listed in the preferred order of deployment, based on their capacity to reduce environmental impact from emissions.

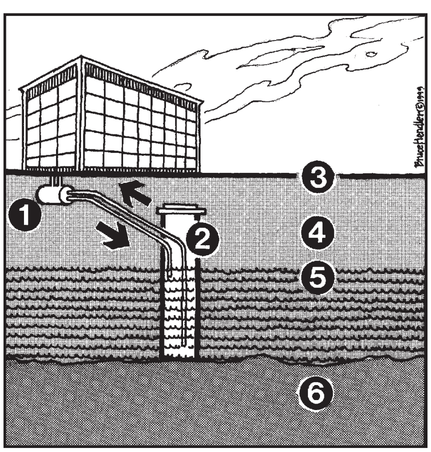
Technical Strategies

The systems described below should always be selected with an awareness of the training and resource needs of on-site operating engineers in order to ensure that these systems are properly operated and maintained. Consider the following technologies:

- ❑ **Renewable Energy Resources.**
  - ❍ Photovoltaic (PV) panels in place of exterior wall and roof panels (building-integrated PV) to generate electric power for the building.[51]
  - ❍ Daylighting techniques that supplement or replace electric lighting.
  - ❍ Solar energy technologies for heating. Passive solar heating can work in portions of buildings such as lobbies, corridors, and atriums of large institutional buildings.
  - ❍ Solar hot water technologies can supplement domestic hot water heater reservoirs, especially in circumstances where large amounts of hot water are required (such as for laundry facilities).

Photovoltaic Cells-Rikers Island
These photovoltaic cells are integrated into the roof of the composting facility on Rikers Island in New York City. The power generated is used to offset the power requirements of the facility.
Photo: Joyce Lee

- ❑ **Super-Efficient and Hybrid Technologies.**
  - ❍ Geothermal heat pump technologies should be considered when subsurface conditions allow. Of available geothermal technologies, a vertical standing column well is generally most applicable to the urban context.
  - ❍ Fuel cells to provide electricity for off-the-grid sites and to support continuous base loads.
  - ❍ Heat recovery from mechanical systems and electric generation, including process heat, steam condensate, fuel cell waste heat, and exhaust air.
- ❑ **Conventional Fuel Source Options.**



Geothermal Heat Exchange Technology
The standing column well illustrated here is a geothermal heat exchange technology that is well-suited for use in developed urban areas since it draws heat from the earth in the winter months and deposits excess heat into the earth in the summer through vertical wells that can be located directly under or adjacent to a building.
❶ Heat pump
❷ 6” diameter “standing column”
❸ Ground level (surface)
❹ Soil (depth varies)
❺ Water table (depth and extent vary)
❻ Bedrock (depth varies).
Illustration: Bruce Hendler

▶ **Benefits**

$\$O_F$
Reduces operating energy expenditures.

$\$D_S$
Helps promote expanded market for renewable technologies.

$\$A_S$
Reduces dependence on fossil fuel generation, with commensurate reduction in air pollutants.

E_S
Avoids environmental damage resulting from fossil fuel extraction/shipment.

51. Note that with the exception of ‘pilot demonstrations’ of emerging technologies, the City’s current agreement with the New York Power Authority (NYPA), the main supplier of electricity to NYC municipal buildings, prohibits the City from generating power independently of NYPA. However, NYPA is open to owning, operating, and metering power generation facilities, such as PV fields and fuel cells, on City property.

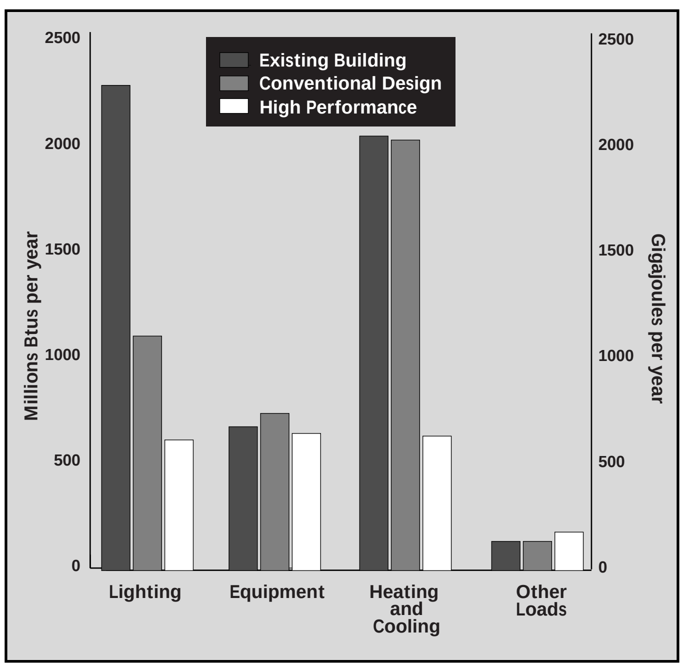
- ❍ When available, electric utility company steam (generally a by-product of electric power generation), should be used for heating, cooling, hot water heating, steam driven pumps, and other applications as warranted.
- ❍ Dual fuel boilers can primarily be operated on natural gas to reduce air pollution, and can be switched to oil only when required.
- ❍ During periods of high demand for electric power, gas powered equipment will provide an economical alternative to electric equipment. In specifying and locating these systems, designer should be aware of equipment noise levels.
- ❍ Lighter grades of oil for oil burning equipment burn cleaner and produce less air pollution.

❑ **Demand Reduction Strategies.**

- ❍ Thermal storage systems work well in conjunction with conventional chiller systems to shift electric power consumption from periods where power is very expensive to periods where cost is lower.
- ❍ Peak-shaving strategies rely on energy management systems, such as those that control ventilation fans by using CO_2 sensors. These sensors help ensure adequate ventilation and good indoor air quality while reducing peak loads.

❑ **Developing Technologies.**

- ❍ Developing technologies include alternate energy sources such as methane from biological processes, micro-generators for on-site tri-generation, hydrogen and so on. These should be investigated based on building location and the availability of the fuel source and technology.

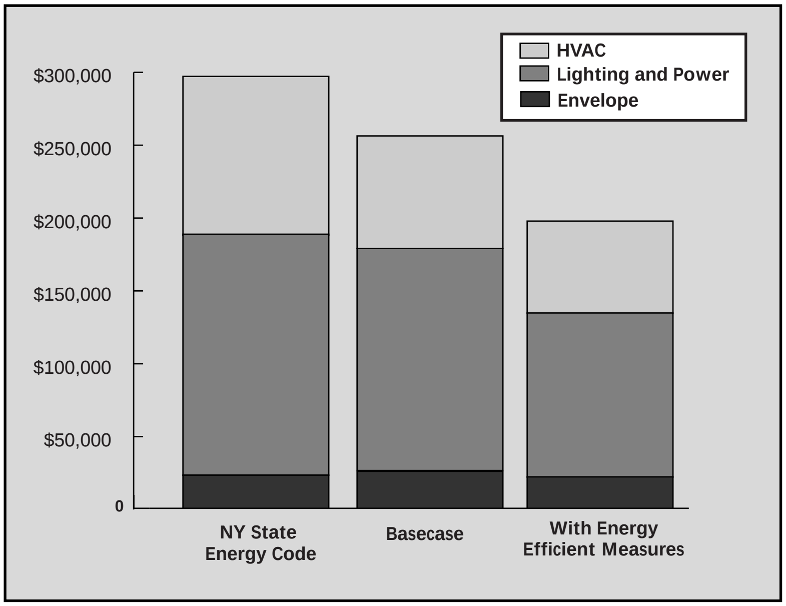


The Ridgehaven Building, San Diego
Breakdown of calculated energy loads for the Ridgehaven Building, showing 1) existing building, 2) conventional design, and 3) as built with high performance features, such as solar control films on glazing, energy efficient lighting, and high efficiency water-source heat pumps.

Source: City of San Diego

Mechanical Systems

Mechanical systems must work in concert with the building layout, orientation, envelope, lighting strategies, electrical equipment, and site characteristics to reduce reliance on energy derived from fossil fuels, and to increase the use of renewable energy.



New Children's Center, NYC Administration for Children's Services, Annual Energy Cost by End Use
At this new foster care/training facility, energy efficiency measures incorporated during design are estimated to achieve roughly 30% reduction in energy usage above NYS Code and 20% savings above a base case of good current professional practice.
Source: Steven Winter Associates

▶ **Benefits**

$\$O_F$
Diminished heating and cooling loads reduce operating energy costs.

$\$O_F$
Right-sizing of equipment results in increased operating efficiencies.

$\$C_F$
First-cost savings can be achieved by specifying appropriately-sized mechanical systems.

$\$A_S$
Limiting electrical and fossil fuel use reduces air emissions, both from power plants and at the building site.

Technical Strategies

- ❑ **Performance improvement.** In all design and construction efforts, strive to improve energy performance well beyond the basic requirements of the NYS Energy Code, applicable regulations, and consensus standards. Determine the overall environmental impact of building energy consumption. Energy performance analysis shall account for energy losses incurred during delivery from the point of generation to the point of use, as well as for the emissions generated by energy production (on and off-site).
- ❑ **Systems integration.** Consider the architectural features (orientation, exposure, height, neighboring structures, present and future landscaping, various options for the new building envelope, future interior lighting, and the occupancy of the building) when selecting HVAC alternatives and sizing the systems.
- ❑ **Zoning.** Use separate HVAC systems to serve areas with different hours of occupancy, perimeter versus interior spaces, special occupancies such as computer rooms requiring 24-hour operation, spaces with different exposures, etc.
- ❑ **Natural ventilation.** Determine if the building might benefit from the use of natural ventilation. For buildings in quiet zones and with clean outside air, consider natural (in lieu of mechanical) ventilation during the swing seasons.
- ❑ **Distribution systems.** Analyze the benefits of variable air volume systems vs. constant air systems; seek reductions in system load during periods of reduced demand.
- ❑ **Gas heater/chiller.** Consider the use of a combination gas heater/chiller to reduce energy costs (and possibly) to reduce the equipment room size.
- ❑ **Distributed mechanical rooms.** Consider independent mechanical rooms on each floor to reduce ductwork and enhance the balance of delivered air.
- ❑ **Heat recovery systems.** Evaluate opportunities for heat recovery systems (sensible and latent).
- ❑ **Partial load conditions.** Select high efficiency equipment that operates at high efficiencies under both full and partial load conditions.
- ❑ **Modular boilers.** Consider installation of multiple modular boilers that allow more efficient partial-load system operation.
- ❑ **Do not use CFC/HCFC refrigerants.**
- ❑ **Condensing boilers.** Consider the use of high efficiency condensing boilers.
- ❑ **Chiller sizing.** Evaluate various sizes and models of chillers to identify unit(s) that will most efficiently meet demand requirements.
- ❑ **Ice storage.** Consider the application of an ice or water storage system as a means of avoiding peak loads for cooling.

- ❑ **Emission controls.** Emission controls must comply with the latest federal regulations.
- ❑ **Dessicant dehumidification.** Consider dessicant dehumidification as an alternative to the conventional practice of overcooling outside air to remove latent heat (moisture) prior to removal of sensible heat.

New Bronx Criminal Court Complex
In the design of the new 750,000 s.f. Bronx Criminal Court Complex, computer modeling of building energy use led to the selection of a 1,000 ton engine-driven gas chiller in combination with two 1,000 ton electric centrifugal chillers. The computer model showed that this chiller configuration has the greatest 25-year life cycle cost savings ($1,117,000), when compared to other chiller equipment options. Though it has a higher first cost, the gas chiller significantly reduces the cost of operation by avoiding the peak electrical demand charges ($30/kW) billed during the summer.

Energy Load Management

Benefits ◀

O_F
Operating cost reductions are achieved through improved matching of heating and cooling loads with central equipment.

C_F
Higher first costs for installation of controls can be offset by operating savings. However, advanced control systems eliminate oversizing of mechanical systems, thus lowering first costs for central systems. Equipment life can be extended by reducing the hours of operation and eliminating unnecessary cycling.

P_F
Improved occupant comfort.

A_S
Limiting electrical and fossil fuel use reduces air emissions both from power plants and at the building site.

D_S
Load management enhances the market for high performance control systems.

The management, continuous calibration, and maintenance of energy-related systems is often neglected, yet these are the only ways to optimize the life and performance of the systems and minimize the damage caused by fossil fuel use. Effective energy load management is a two-step process, consisting of load measurement and system response. Continuous calibration of sensors and instrumentation will yield top mechanical system performance in terms of energy use and comfort.

Technical Strategies

Load Calibration

- ❑ **Energy management system (large buildings).** An energy management system encompassing all building controls should be considered for all new buildings exceeding 40,000 sq. ft. For existing buildings of this size, an energy management system encompassing all building controls shall be provided when undertaking a complete renovation of the mechanical systems.
- ❑ **Energy management system (small buildings).** An independent advanced control system or energy management system (as determined by economic analysis) should be considered for smaller buildings.
- ❑ **Monitoring and controls.** Energy monitoring and control systems should provide:
  - ❍ Energy consumption monitoring using hourly graphs to illustrate the effects of small operational changes and monthly graphs that depict historical trends and operating information over time.
  - ❍ Controls (including load tracking and load anticipation capability) that optimize system response to building pickup and download.
  - ❍ Load shedding and peak electric demand reduction through scheduled equipment cycling or through use of non-electric powered equipment. (For example, use of gas chillers).
  - ❍ Local controllers capable of independently managing equipment operation and gathering data for reporting. Carefully select the components of the mechanical/electrical systems being controlled for software compatibility. Ensure that all software required to operate the system is provided; ensure that software upgrades are received and loaded in a timely manner. Provide training materials and manufacturer maintenance contracts for all installed systems to operating personnel.
- ❑ **Selection of control method components.** The control methods used to improve the efficiency of HVAC systems should include a building automation system, as appropriate. These systems are usually compatible with Windows®-based workstations. Subsystem integration should be accomplished using a BACnet open protocol to ensure compatibility with different components and subsystems.
- ❑ **Systems integration.** Assess the interactions between the HVAC equipment and other related systems, such as lighting, office equipment, fire protection, security, etc. Determine optimum operating modes for each system.
- ❑ **Computerized control system.** Use a computerized control system to establish, maintain, and document building climate conditions. Accept only control systems with the capability to adjust set points, without the need for complete reprogramming. Control systems should be designed or specified to a level of complexity that's appropriate for the staff who will be supporting its use.

- ❑ **Control back-up systems.** Provide simple back-up controls so that equipment can function if the energy management system goes down. Depending on the complexity of the building and the equipment to be controlled, include the following control strategies in the energy management system as a means of ensuring efficient operation:

System Response

- ❑ **Heating equipment.** When reviewing options for boilers, consider the following:
  - For larger boilers, oxygen trim controls to improve combustion efficiency.
  - Draft control inducers which reduce off-cycle losses.
  - Demand control for larger boilers, based on variations in heating demand.
  - Water reset control keyed to outside air temperature.
  - Burner flame control.
  - For small renovation projects, provide a time clock for night and weekend set backs.
- ❑ **Air conditioners, chillers and ventilation controls.** The following strategies will help get the most out of these key systems:
  - Generate energy consumption profiles that identify occurrences of peak loads and develop responsive management strategies for reducing utility bills.
  - Set up the HVAC building control system to operate based on need. If multiple sources are available, minimize simultaneous heating and cooling, and supply thermal conditioning from the most appropriate/efficient sources.
  - Limit electrical demand during peak hours by turning off non-essential equipment.
  - Establish temperature and humidity setpoints based on occupancy patterns, scheduling, and outside climate and seasonal conditions.
  - Consider CO_2/VOC (carbon dioxide/volatile organic compound) sensors to reduce outside air ventilation in large spaces with variable occupancy. Verify that specified settings are consistent with local and national code requirements.
  - Provide sensors that are capable of adjusting the ventilation rate based on the number of people present in a room. Locate sensors accordingly.
  - Provide adaptive, programmable thermostats capable of automatically adjusting settings based on recorded demand patterns. This prevents ‘overshooting’ or ‘undershooting,’ and can result in energy savings of 10-20%.
  - Set supply air-temperature reset controls for variable air volume (VAV) systems based on space occupancy.
  - Control strategies for chilled water plant operation include:
    - Chiller speed control through variable speed drive controllers, selection of modular chillers or chillers with multiple compressors, and chilled water reset.
    - Condenser water reset.
    - Chiller sequencing.
    - Soft-starting of chiller motor.
    - Demand control.
    - Use of two-speed motors or multiple units for pumps/fans.
    - Use of variable speed controllers for fans and pump motors.
  - For small buildings, use time clocks with night and weekend set-backs for HVAC equipment.

Building Integration

Site Design and Planning. Landscape design can either enhance or undermine the climate-related heating and cooling of the building.

Indoor Environment. Orientation, massing, and siting significantly impact access to daylight and the success of daylighting strategies.

Indoor Environment. Consider daylight transmittance as well as thermal characteristics when selecting spectrally-selective (low-e) glazing.

Material and Product Selection. When specifying materials for their thermal and water-resistant properties, also consider their effects on indoor air quality, resource-efficiency, and occupant health.

Operations and Maintenance. Encourage future building users (or present users for renovation projects) to take part in decisions relating to building occupancy, hours of operation, operating personnel, and maintenance considerations.

Performance Goals

New York State regulations stipulate the performance benchmark for new and renovated commercial buildings: the New York State Energy Conservation Construction Code. Frequently referred to as the NYS Energy Code, these energy performance criteria became law in 1979 and were last amended in 1989. The NYS Energy Code establishes the *minimum* building construction and mechanical system efficiencies that can legally be used in New York State. These minimum standards fall short of much of what's currently taking place in commercial building practice. As a result, the NYS Energy Code is now under review, and should soon be updated to reflect current technology and practice – particularly in the area of lighting.

Despite these limitations, the Code can still serve as a useful benchmark for gauging progress. Thus, the following whole building performance goals have been cast in relation to this benchmark, but leave ample room for improvement. To determine the quantity of source Btus consumed, the conversion factor of 1 kilowatt hour being equal to 10,000 Btus should be used (as stipulated by the NYS Energy Code).

PERFORMANCE GOALS

Building
Energy Use

LEVEL 1

- ❑ **New Buildings.** High performance new buildings shall annually consume a minimum of 30% less energy on a Btu-per-gross-square-foot basis in comparison to what would be consumed if the building were designed for minimum compliance with the NYS Energy Code. Operational cost comparisons should be prepared to ensure that the high performance building will save at least the same percentage in energy costs as it achieves in combined actual energy use reductions.

  In addition, it shall be a goal of Level 1 high performance buildings that, at minimum, 10 percent of the total annual energy use, or one-third of total annual energy savings, should be provided by renewable energy sources. In performing this calculation, no credit shall be taken for design features that are required by the NYS Energy Code, such as the use of an economizer cycle to provide cooling with outside air when favorable outdoor conditions exist.

  For all applicable perimeter spaces, produce a design that yields a minimum daylight factor[52] of 1.5% on the work plane at a depth of 15 feet from the building exterior. Control quality issues such as glare, veiling reflections, and contrast so that daylight does not hinder activities scheduled for the space. Achieve Illuminating Engineering Society of North America (IESNA) footcandle requirements for scheduled use through integration of daylight into lighting design.

- ❑ **Fully Renovated Buildings.** Fully renovated Level 1 high performance buildings, wherein the entire envelope (e.g., windows, walls, roof, etc.), HVAC, and lighting systems are fully upgraded or replaced, should have the same performance goals as new buildings.

- ❑ **Partially Renovated Systems.** In buildings where a major subsystem (such as lighting or windows) are replaced, the goal is to use systems that will consume significantly less energy than those that merely comply with the NYS Energy Code.

LEVEL 2

- ❑ **New Buildings.** New buildings shall annually consume a minimum of 40% less energy on a Btu-per-gross-square-foot basis than what would be consumed if the building were designed to achieve compliance with the NYS Energy Code. Operational cost comparisons should be performed, and the high performance building should save at least the same percentage in energy costs as it does in combined energy source reductions.

  In addition, a minimum of 20 percent of the overall annual energy use, or one-half of the annual energy savings should be provided by renewable energy sources. In performing this calculation, no credit shall be taken for design features that are required by the NYS Energy Code, such as the use of an economizer cycle to provide cooling with outside air when favorable outdoor conditions exist.

  Produce a design that yields availability of daylight to a depth of 30 ft. (with a minimum daylight factor of 3.0% on the work plane at a depth of 15 feet from the building exterior) through use of redirecting devices such as light shelves. Control quality issues such as glare, veiling reflections, and contrast so that daylight does not hinder activities scheduled for the space. Achieve IESNA footcandle requirements for scheduled use through integration of daylight into lighting design.

- ❑ **Fully Renovated Buildings.** Fully renovated buildings, wherein the entire envelope (e.g., windows, walls, roofs, etc.), HVAC, and lighting systems are fully upgraded or replaced, should have the same performance goals as new buildings.

- ❑ **Partially Renovated Systems.** In buildings where a major subsystem (such as lighting or windows) is replaced, the goal is to use systems that result in significantly reduced energy use in comparison to those that merely comply with the NYS Energy Code. Best engineering judgment should establish appropriate targets for a particular project. In the case of Level 2 performance, aggressive targets shall be established.

Building
Energy Use

52. Daylight factor: The percent of light available inside a building at a given point, as compared to the illumination level available outdoors at that time on a horizontal surface under overcast sky conditions.

Tools

Economic Feasibility Evaluation

Analysis for architectural, mechanical, and electrical systems:

➤ Cost analysis begins by performing a 'simple payback analysis' of specific design strategies on an individual basis. Promising candidates should then be evaluated in interactive combinations. It is important to note that, while the resources available to cover the first cost of energy efficiency measures will vary by project, a 'simple payback' of first costs by projecting savings in operating costs over a period of seven (7) years may serve as a rule of thumb when evaluating whether a given combination of energy efficiency measures are economically viable. For example, a building envelope improvement with a 12-year payback may be factored together with a lighting improvement with a 4-year payback to yield a combined payback of under 7 years. It is also important to note that the anticipated life of the measure should be considered when evaluating economic viability. For instance, a longer payback period may be appropriate in a new building for an envelope component such as insulation, which may last over 50 years, as opposed to lighting controls with a life expectancy of only 25 years. Maintenance costs, if considered unusual for a proposed measure, may also be factored into the analysis at this stage.

➤ In some instances, cost credit may be given for reductions in HVAC equipment sizes, based on comparisons to industry standards. Use an 'adjusted simple payback analysis' that considers the reduced equipment and system size cost benefits, as well as incremental first costs and reduced operating costs resulting from given energy efficiency measure(s).

Analysis for mechanical and electrical equipment:

➤ Life cycle cost analysis should be used to identify mechanical and electrical equipment alternatives. This analysis should be based on first cost of equipment and projected energy costs over the equipment's anticipated life cycle.

➤ The life cycle cost calculations shall be performed for as many architectural and mechanical/electrical alternatives as required in the Consultant Contract (include the requirement for life cycle analysis in the Specific Requirements) and as requested during Design Development by DDC/Sponsor to their complete satisfaction.
The current inflation rate and anticipated fuel price changes shall be obtained from the DCAS Office of Energy Conservation (OEC).

Energy Modeling Tools

➤ Trace 600 – Developed by Trane Corp. to support HVAC design criteria, space heating and cooling load calculations, free cooling and heat recovery, thermal storage, chilled water piping arrangements, etc.

➤ DOE-2.1E – Detailed, hourly, whole building energy analysis of multiple zones and multiple lighting/HVAC systems for complex new buildings. This program also features an extensive library of glazings. It is currently the most accurate program available for performing energy analyses on entire buildings.

➤ HAP v4.0 – Hourly Analysis Program developed by Carrier Corp, an energy simulation module that performs an 8760-hour energy simulation of building heat flow and equipment performance.

➤ BLAST – Building Loads and System Thermodynamics performs hourly simulations of buildings and central plant equipment, and zone analysis based on the fundamental heat balance method. Analysis of thermal comfort, passive solar structures, high- and low-intensity radiant heat, moisture, and variable heat transfers coefficients is also within the program's functionality.

- ➤ TRNSYS – The Transient System Simulation program is used for HVAC analysis and sizing, solar design, daylighting, building thermal performance, PV, wind, analysis of control schemes, etc.
- ➤ Designing Low-Energy Buildings with ENERGY-10 – A whole building design tool that is ideal for use during the pre-design phases of moderate (up to roughly 50,000 sq. ft.) projects. Includes a set of whole building design guidelines and software for performing energy and cost calculations based on local climate, building orientation, materials, systems, and the interactions among them. Program upgrades are expected to address larger structures.
- ➤ ADELINE and RADIANCE – These specialized design tools are also available to evaluate daylight, air flows (CFD), three-dimensional heat flows, and other design considerations.
- ➤ HEATING-7 and ALGOR – These programs quantify and illustrate airflows (computational fluid dynamics, or CFD) and three-dimensional heat flows, etc.
- ➤ ASEAM – A Simplified Energy Analysis Method that can also create DOE-2 input files. This is easier to use but less accurate than DOE-2.
- ➤ FRESA – Federal Renewable Energy Screening Assistant assesses the feasibility of various renewable energy applications, including active solar heating, active solar cooling, daylighting with windows, skylights, photovoltaics, solar thermal electric, wind electricity, small hydropower, biomass electricity, cooling load avoidance, infiltration control, and so on.

Deliverables

Pre-Preliminary. When preparing the Operating Energy Analysis section of the High Performance Plan *(see page 37-39)*, be sure to include the following elements:

- ❍ Analysis of energy use in similar building types. The energy use of comparable high performance buildings should inform the project's performance goals. Standard industry practice should also be established by the Consultant for use as a baseline against which the effect of proposed improvements may be measured. For renovations, an analysis of the previous three years of monthly energy consumption (including gas, oil, electric usage, and electric demand) would serve as a viable baseline for gauging improvement.
- ❍ Performance goals for operating energy costs should also be established, based on the above analysis.
- ❍ Establish performance goals for renewable energy use, and identify renewable options based on availability and adaptability to the project at hand.
- ❍ Determine the proposed methodology for improving and analyzing the building design's energy performance, including appropriate energy modeling software.
- ❍ Establish goals for lighting and power density for the project as a whole and for all typical major spaces. Lighting and power density should each be reported in two ways: first as the amount available for use, and second as a potential source of heat gain.

Schematic Design Phase. Prepare an analysis that includes the following:

- ❍ An evaluation of alternative massing, orientation, layout, and envelope alternatives for the project based on the methodology proposed for use in the pre-preliminary phase. Using pre-preliminary data on lighting and power and assuming a likely HVAC option, perform heating and cooling load calculations at a level of detail appropriate to each design alternative. Confirm that each scheme can fit within the proposed energy budget. Propose alternate types of HVAC systems and discuss how each will potentially interact with features of the architectural design. At this stage, calculations for various HVAC alternatives will likely be approximate in nature, and are intended only to assess whether systems under consideration will warrant further examination during Design Development.

Design Development. Prepare an analysis that addresses the following:

- ❍ Based on the accepted architectural scheme and the targets for lighting and power, examine the various central plant design alternatives and propose feasible, effective means of integrating renewable energy sources into their operation. Provide life cycle cost and emissions analyses for each alternative.
- ❍ Based on central plant selection, examine energy efficient strategies for controlling temperature and ventilation air, for lighting and lighting controls, and for envelope improvement. A separate life cycle cost analysis shall be prepared for each of the alternatives. Recommended components shall be those with a reasonable payback relative to the anticipated life of the item proposed. A final life cycle cost analysis of recommended design elements analyzed in combination with one another shall be prepared to confirm and further elucidate results.
- ❍ Document assumptions and calculations leading to size recommendations for chillers and other equipment. Documentation should include an analysis of plug load and should specify electrical equipment type relative to nameplate rating, power consumption in active and standby modes, time in active mode, number of devices, etc. It should also include all other assumptions that influence chiller sizing, such as occupancy schedule and envelope loads.

Construction Documents

- ❍ Based on refinement of the building envelope and additional data developed during the Design Development Phase, revise the heating and cooling load calculations and update your analyses of the selected efficiency measures.
- ❍ Regulatory Constraints
- ❍ For ventilation, high performance recommendations may require confirmation of compliance with NYC Building Code.
  (See Appendix G, Required Minimum Outdoor Air Supply and Exhaust).

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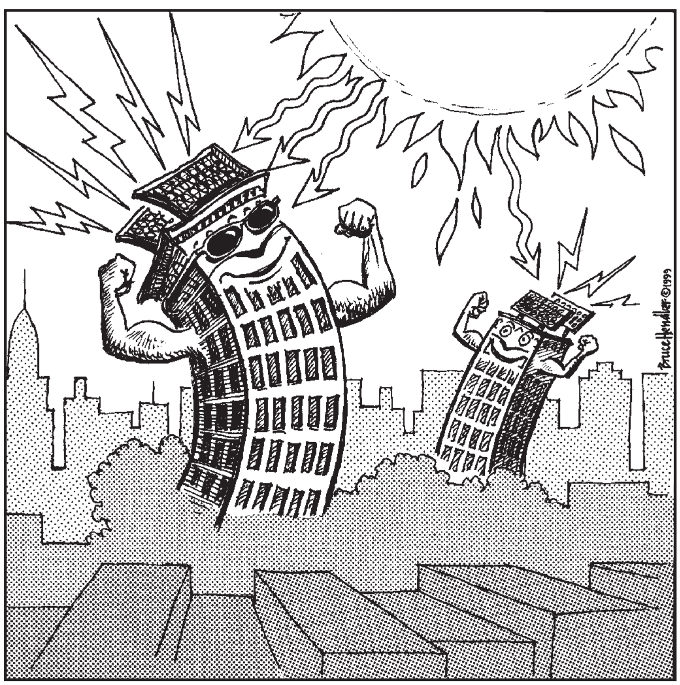


Illustration: Bruce Hendler

Indoor Environment

High performance buildings reflect a concern for the total quality of the interior environment. By definition, they provide supportive ambient conditions, including thermal comfort and acceptable indoor air quality, visual comfort, and appropriate acoustical quality.

Air temperature, mean radiant temperature, air speed, and humidity are all factors that affect thermal comfort. Dissatisfaction with thermal conditions is the most common source of complaints in office buildings. Small changes (on the order of 1-2° F) in air temperature may significantly affect thermal comfort. The American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) in its Standard for Acceptable Comfort, 55-1992, and its addendum, ASHRAE 55a-1995 *Thermal Environmental Conditions for Human Occupancy*, describes comfortable temperature and humidity ranges for most people engaged in largely sedentary activities. For the purposes of this chapter, thermal comfort is included in the section on Indoor Air Quality.

Acceptable indoor air quality was defined in the draft revision to ASHRAE 62-1989 as *"air in an occupied space toward which a substantial majority of occupants express no dissatisfaction and in which there are not likely to be known contaminants at concentrations leading to exposures that pose a significant health risk."*

Visual comfort is a function of many variables, including lighting quality (e.g., illuminance or intensity of light that impinges on a surface, the amount of glare, and the spectrum of the light), visual contact with the exterior, and availability of natural lighting.

Acoustical quality is obtained through appropriate noise attenuation through the building envelope, control of equipment noise, and efforts to block flanking sound paths through fixed walls and floors, and to isolate plumbing noise.

Increased attention to these environmental features can boost quality of life in the workplace by improving overall physiological and psychological well-being. By making the project team accountable for improving building interiors, the City can achieve better human resource outcomes: avoidance of sick building syndrome, reduced occupant complaints, lower rates of absenteeism, improved occupant health, and potentially improved occupant performance.

Indoor Environment

INDOOR AIR QUALITY

Good indoor air quality encompasses such factors as maintenance of acceptable temperature and relative humidity, control of airborne contaminants, and distribution of adequate ventilation air. It requires deliberate care on the part of the entire project team. Achieving thermal comfort begins with good design and continues with proper building management, and seeks to avoid uneven temperatures, radiant heat gains or losses (e.g., from window areas), draftiness, stuffiness, excessive dryness, or high relative humidity (that can promote growth of mold and mildew). Through careful selection of materials, designers will avoid introducing potential pollutant sources. Mechanical engineers and allied tradespeople must select and install reliable ventilation systems that dilute the by-products of occupant activities and, to the greatest extent possible, supply fresh air on demand in the right quantities, in the right locations. During construction, air passageways need to be protected and mechanical systems must be balanced and commissioned to achieve optimal operation. Facility managers and maintenance staff also play a role in keeping areas clean while minimizing the use of irritating cleaning and maintenance supplies.

Even if all objectives are met, attaining an indoor air quality that's acceptable to all may be difficult to achieve, owing to the diversity of sources and contaminants in indoor air, as well as occupant perceptions and individual susceptibility.

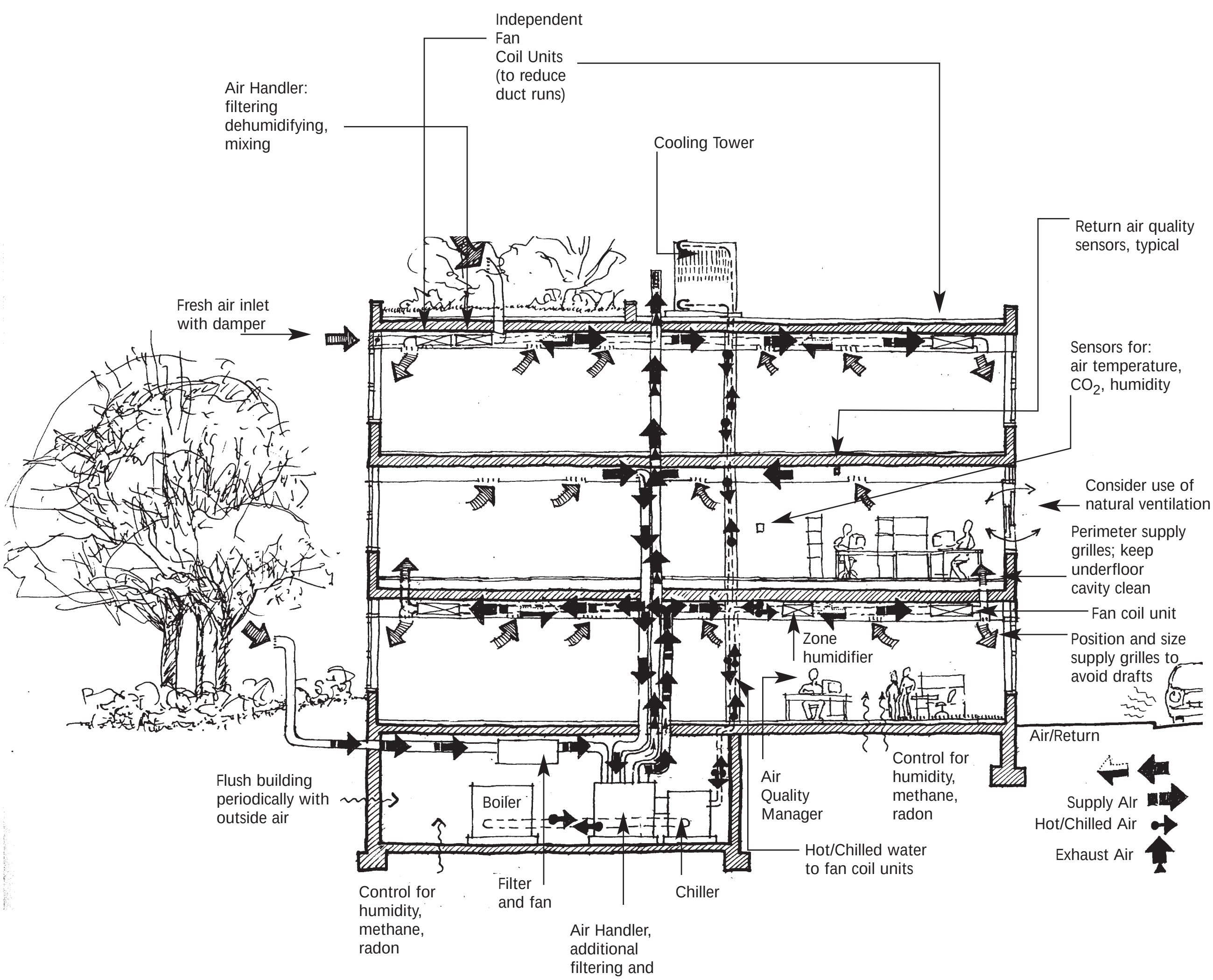
Good Indoor Air Quality (IAQ)

A healthy and comfortable level of indoor air quality is the goal for all occupied spaces, as good IAQ supports and enhances the activities and well-being of the occupants.

Benefits ◀

P_F$

Improved indoor air quality increases occupant comfort, alertness, and sense of well-being. It also reduces absenteeism and lowers health care costs linked to upper respiratory discomfort and illness. There may be additional links to worker performance resulting in improved productivity.



Attributes of Good Indoor Air Quality

Illustration: Johannes Knesl

Carbon Dioxide Sensors

In the design of the New Bronx Criminal Court Complex, a 750,000 s.f. facility, the amount of carbon dioxide (CO_2) released by occupants in the courtrooms and jury deliberation rooms will be measured by CO_2 sensors. The CO_2 measurements, which reflect the number of occupants in the space, will adjust the volume of tempered outside air introduced to the space. Thus, when many occupants are present, more tempered (heated or cooled) outside air will be introduced to the space. Conversely, tempered air volume will be reduced when the space has only a few occupants. The amount of tempered outside air is thus supplied in direct proportion to the number of occupants present, rather than at rates unrelated to occupancy. In this project, CO_2 sensors were configured to meet a 15 c.f.m.per occupant outside air requirement, which ensures that indoor air quality is achieved without sacrificing energy efficiency.

Technical Strategies

Dealing with air quality as an add-on issue during design or construction is difficult, expensive, and less effective than including good indoor air quality strategies at the outset. These fall into several categories and are prioritized as follows:

- **Source Control** (*a primary strategy*).
  - Evaluate sources of contamination from neighboring buildings and soil contamination, such as radon, methane, and excessive dampness. Incorporate measures to prevent soil gas from being drawn into the building. Waterproof the slab-on-grade to limit moisture transport.
  - Locate and design air intakes to optimize air supply source(s) for the ventilation system. Isolate building air intakes from building exhaust air, vehicular exhaust, cooling tower spray, combustion gases, sanitary vents, trash storage, and other hazardous air contaminants.
  - Reduce potential pollution sources through effective moisture control.
    (See page 58 in the Building Energy Use chapter).
  - Specify materials with low volatile organic compounds (VOCs) and low odor emissions.
    (See pages 93-94 in the Materials and Products chapter for detailed information.)
  - To avoid occupant exposure to airborne pollutants, perform cleaning and pest control activities when the building is largely unoccupied.
- **Ventilation** (*a secondary strategy*).
  - Develop ventilation strategies that support operable windows, where appropriate to the site and function.
  - To avoid stagnant air in occupied spaces, design for at least 0.8–1.0 c.f.m./ft^2 air movement.
  - Isolate potential pollution sources through separate zoning of areas where contaminants are generated.
  - Design mechanical systems that can provide and maintain the required ventilation rate. Design ventilation system for high air change effectiveness; avoid short-circuiting supply air to return registers.
  - Specify ventilation systems that feature an economizer cycle. This will allow 100% of outdoor air into the supply airstream and enables periodic building flushing, as well as cooling during mild weather. Design and control HVAC economizers so as to prevent moisture problems.
  - Consider supplying ventilation air primarily to occupied zones using distribution systems such as underfloor air ducting. The resulting floor-to-ceiling indoor airflow pattern (also known as displacement ventilation) can be used to reduce pollutant concentrations in occupied spaces.
  - For spaces designated in the Environmental Program Matrix, locate CO_2 or other IAQ sensors to accurately reflect conditions and control outside air quantities.
  - Avoid rooftop units because of inaccessibility for maintenance. (Such placement may preclude use of rooftop space for other purposes.) Wherever possible, install air handling units in accessible locations.
  - Use rainproof louvers and limit intake air velocities to discourage water intrusion.
  - To prevent wetting downstream surfaces, select proper air velocities through cooling coils and humidifiers.

- ❍ Provide filtration capable of 60% (or greater) dust spot efficiency,[53] installed to intercept all make-up and return air. If the outdoor air has high dust levels, use higher efficiency air filters (80-85% ASHRAE standard efficiency with 30% efficiency pre-filters).
- ❍ Consider use of low pressure drop, high efficiency air filters.[54]
- ❍ Avoid the use of fibrous duct liners and loose mineral fiber for internal ductwork insulation. These products have a high potential for dirt accumulation and dampness leading to mold growth, and may be prone to fiber release into conditioned spaces. Use non-porous duct liners, external thermal insulation, or acoustical baffles in lieu of linings in strategic locations.
- ❍ Prevent condensation of water vapor inside the building envelope by proper use of moisture barriers, appropriate locations and amounts of thermal insulation, control of indoor-to-outdoor pressure differences, and control of indoor humidity.
- ❍ Commission the ventilation system to assure that design conditions are met, proper air delivery occurs in each zone, and optimum performance is achieved under full and partial load conditions. *(See Commissioning Chapter.)*
- ❍ Isolate potential pollutant sources through use of appropriate filtration systems and separate zoning of areas generating contaminants.
- ❍ Vent kitchens, toilet rooms, smoking lounges, custodial closets, cleaning chemical storage and mixing areas, and dedicated copying areas to the outdoors, with no recirculation through the HVAC system.
- ❍ Avoid use of ozone-generating devices to clean or purify indoor air.[55]

❑ **Control Systems.**

- ❍ Sensors for relative humidity, temperature, and carbon dioxide should be installed as close as possible to where occupants are located.
- ❍ Locate sensors to cover areas of similar load conditions (similar occupancy and similar solar exposures).
- ❍ When demand control ventilation (DCV) systems are used, ensure that carbon dioxide sensors are operating in a reliable manner. This is achieved through routine calibration.
- ❍ Periodically audit all computer-controlled HVAC systems (e.g., direct digital control systems with graphic interfaces) to verify performance and calibration.
- ❍ Consider personal workstation control of HVAC systems. However, personal controls may result in greater maintenance requirements for dispersed HVAC equipment and controls; such equipment should thus be designed to be accessible for preventative maintenance.
- ❍ Specify controls on variable air volume (VAV) systems to ensure that the amount of outdoor air delivered to the occupants is maintained, even when the total air supply is decreased.
- ❍ In VAV systems, special controls may be needed to ensure that minimum outside air intake into the air handling unit is achieved during all operating conditions.
- ❍ In VAV systems, at minimum, install temperature sensors in return air sections of air handling units to maintain air temperature at acceptable levels.

❑ **Construction Methods/Precautions.**

- ❍ Prevent storage of soft products on site during wet processes, unless separated and sealed; e.g., ‘shrink-wrapped.’
- ❍ Schedule installation of wet materials (sealants, caulking, adhesives) and allow them to dry or cure before installing dry materials that could serve as ‘sinks,’[56] and absorbents of VOCs.
- ❍ Ensure that construction materials such as concrete are dry before they are covered (e.g., with floor tile or carpeting) or enclosed in wall cavities.
- ❍ Ensure that the contractor uses metal ductwork instead of substituting fiberglass.
- ❍ Control fiber or particle release during installation of insulation and require general area cleanup prior to building occupancy.

53. The dust spot efficiency test is a semiquantitative measure of a filter’s collection efficiency for fine particles – those associated with smudging of the interior surfaces of buildings. Upstream and downstream paper target filters collect particles and the opacity (light transmission) is then measured.
54. Extended surface pleated air filters that allow greater air filtration without a significant increase in fan horsepower requirements.
55. EPA has a guidance document on this subject, Ozone Generators that are Sold as Air Cleaners: An Assessment of Effectiveness and Health Consequences, available at http://www.epa.gov/iedweb00/pubs/ozonegen.html
56. Gases and vapors often adsorb, and particles deposit, on surfaces such as carpet, drywall, etc. These surfaces are known as ‘sinks,’ and contaminants can be re-emitted from these repositories at a later time.

- ❍ Flush the building with 100% outside air for a period of not less than 30 days beginning as soon as systems are operable and continuing throughout installation of furniture, fittings, and equipment. A delay in building occupancy can significantly reduce odor and irritancy complaints.

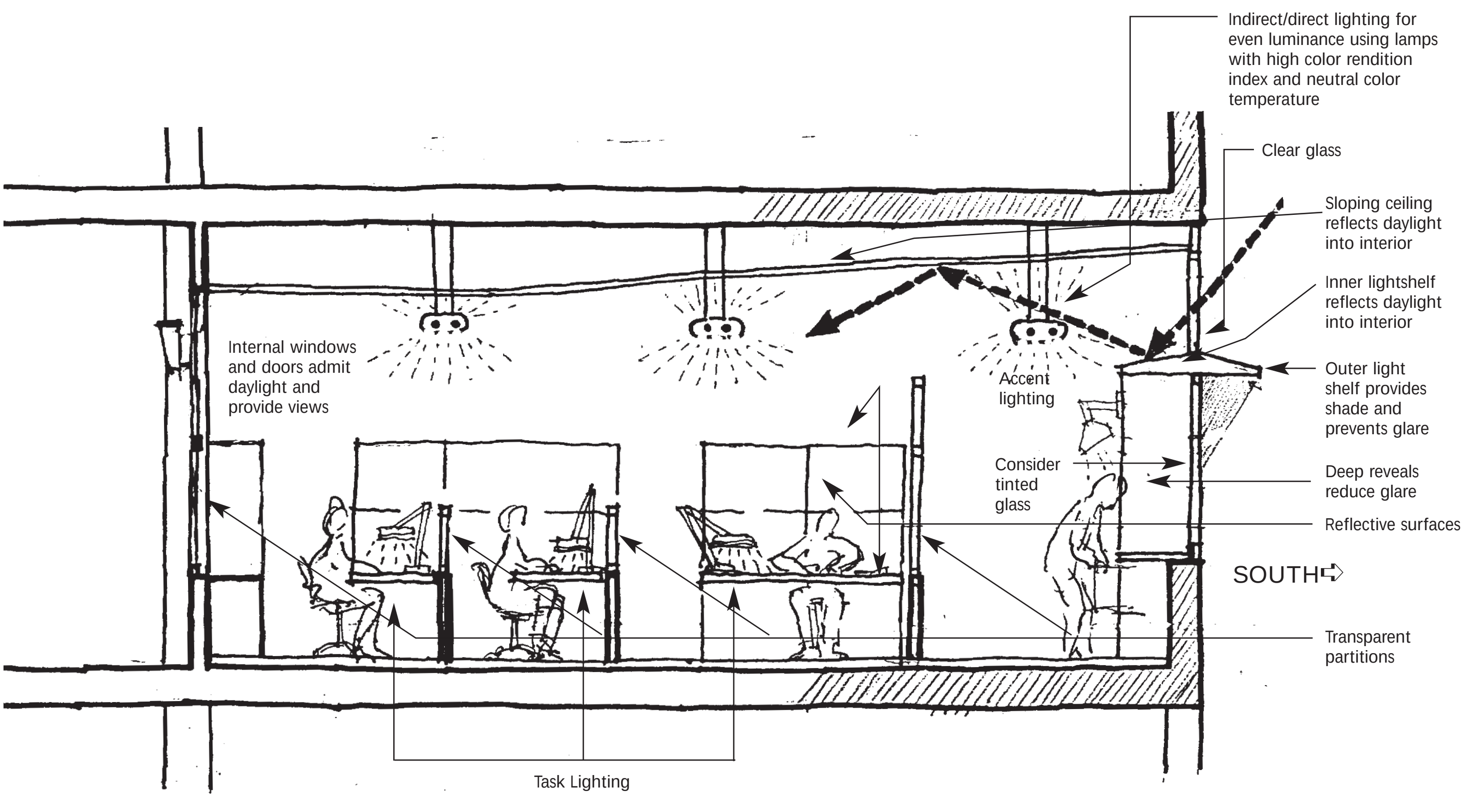
❑ **Occupant Activity Control.**
- ❍ Maintain a 'no smoking' policy.
- ❍ Designate an Indoor Air Quality manager who receives ongoing IAQ training.[57]

❑ **Building Maintenance and Operation**
- ❍ (See page 124 in the Operations and Maintenance Chapter).

❑ **Emerging Technologies.**
- ❍ The technology surrounding ion generators[58] may be of interest to the building owner in specific situations; however, the evidence is not sufficiently conclusive to support a recommendation for use of these devices at this time. Any such device should not generate ozone above the FDA limit of 50 ppb in any occupied space.[59]

GOOD VISUAL QUALITY

The daily rhythm of natural light sets our biological clock. Its seasonal rhythm influences our mood, and its presence is necessary for a number of health-sustaining biological processes. Since most of us spend more than ninety percent of our time indoors, buildings should provide as much daylighting to as many occupants as possible. Daylighting, controlled by building openings, glazing types, and the configuration of reflecting surfaces, offers a rich spectrum that improves visual acuity. Its dynamic changes over the day provide visual stimulation, and keep us connected with the outside world. Electrical lighting systems should complement natural light.



Elements of Good Visual Quality
Illustration: Johannes Knesl

57. For specifics, see the Operations and Maintenance chapter, which references an IAQ Action Plan and the publication *Building Air Quality: A Guide for Building Owners and Facility Managers* developed by EPA to help prevent IAQ problems in buildings. The publication may be downloaded from www.epa.gov/iedweb00/base/baqtoc.html.
58. Ionizers or ion generators charge the particles in a room so that they are attracted to walls, floors, tabletops, draperies, occupants, etc. Abrasion can result in these particles being resuspended into the air. In some cases, these devices contain a collector to attract the charged particles back to the unit. While ion generators may remove small particles (e.g., those in tobacco smoke) from indoor air, they do not remove gases or odors, and may be relatively ineffective at removing large particles such as pollen and dust allergens.
59. American Lung Association, U.S. Environmental Protection Agency, Consumer Product Safety Commission, and the American Medical Association, 1994.

Light Sources

*"If one word could summarize the approach used on Audubon House, it would be **optimization**. If one word could summarize the lost opportunities in how we typically build, it would be **compliance.**"*

Randolph R. Croxton,
FAIA, Audubon House

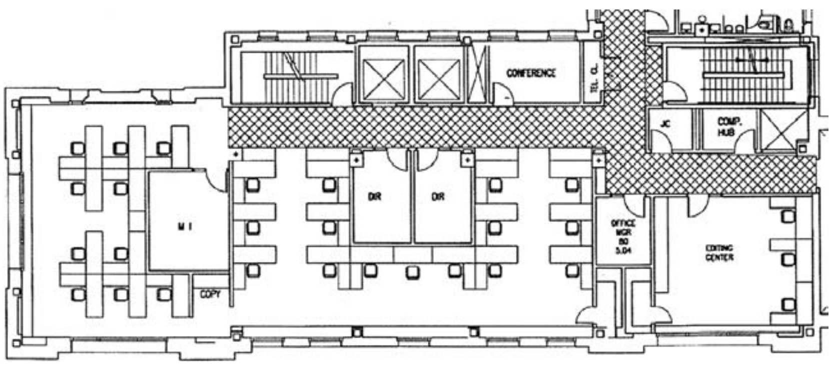
Benefits ◄

$\$P_F$

Daylight and high quality illumination, in tandem with increased visual contact with the outdoors, contributes to occupant comfort and sense of well-being. There may be additional links to worker performance resulting in improved productivity.

Achieve a quality of light that is beneficial to building activities and occupants by combining natural light with complementary electrical light sources.

Audubon House
In the Audubon House building in New York City, daylighting has been incorporated through skylights and borrowed light accessed through openings in the walls of perimeter offices. In addition, the floor layout enables daylighting and views through windows at the ends of corridors and at strategic locations in the circulation system. The south-facing open work areas are equipped with automatic dimmer controls that regulate electrical lighting in response to available daylight. Room surfaces have been chosen for reflectance of indirect light sources to maximize the efficiency of the daylighting and electrical light balance.



New Children's Center NYC Administration for Children's Services
In the layout for the New Children's Center, the open office plan promoted access to the exterior for daylight for the majority of occupants. Managers have private but interior offices. Light shelves were added on the south side of the building to reduce glare and to increase penetration of daylight into the interior.
Richard Dattner Architect, P.C.

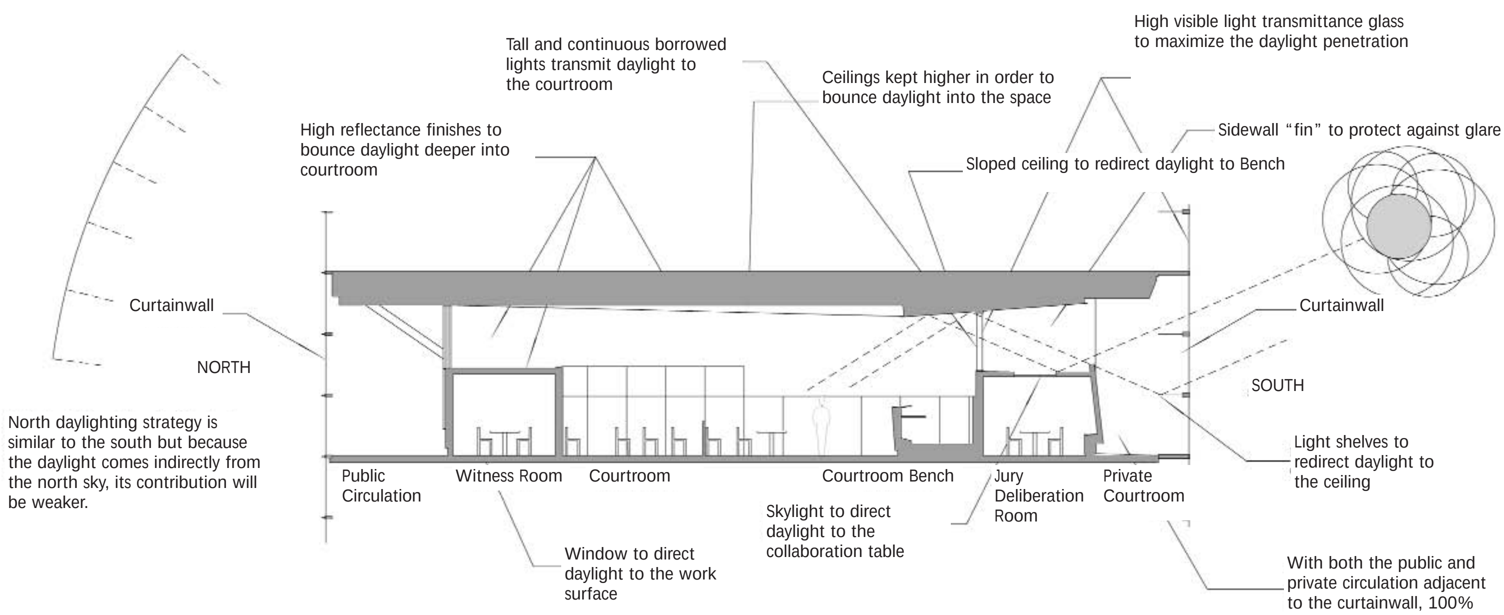
Technical Strategies

- ❑ **Daylighting apertures.** Maximize daylighting through appropriate location and sizing of windows, roof monitors, and skylights, and through use of glazing systems and shading devices appropriate to orientation and space use.
- ❑ **Light shelves, surface reflectance.** Extend window light throw through the use of light shelves, prismatic glazing, or louvers, and through appropriate room surface reflectance and colors. *(See p. 58, Building Energy Use).*
- ❑ **Light distribution.** Where appropriate, encourage use of relatively low general lighting levels and of predominantly reflected light, mainly from the ceiling. This will bring about a light distribution closer in character to daylight and make for a softer visual environment with less potential glare. These conditions are conducive to working on computer screens and allow the individual characteristics of furnishings to come to the fore.
- ❑ **Avoiding glare.** Avoid arrangements of light sources and reflecting surfaces that cause direct or indirect glare (excessive brightness contrasts) and veiling reflections of light sources in visual task areas. Means include use of indirect luminaires or cut-off fixtures; the designer will also want to avoid overlighting of spaces. Use of deep window recesses, low partitions, and strategically located high-reflectance surfaces will also help avoid excessive contrasts and overly dark zones.
- ❑ **Light levels.** Achieve a good balance between uniform light levels and localized variations to create a dynamic and comfortable visual environment. Consider:
  - Low-level ambient lighting augmented by high quality, flexible task lighting.
  - Varied lighting schemes that respond to general building organization and special features.
  - Allowing the lighting patterns to reflect changing activity scenarios during the working day.

- ❑ **Luminaire arrangements.** Arrange luminaires in types and patterns that clearly respond to the fundamental building organization, floor layout, and entry paths of daylight while allowing for flexibility of space usage. Wherever practicable, wire luminaires in parallel to the walls with windows, so they can be dimmed or turned off row by row.
- ❑ **Diffusers.** Select diffusers that reduce glare and sufficiently illuminate ceilings and walls to create a visual field similar to prevailing daylight conditions.
- ❑ **Color.** Provide lamps with high color rendering index, such as tri-phosphor fluorescent lamps. Lamps in the warm-white to neutral-white color (2500° to 3700°) temperature range effectively complement skin tones.
- ❑ **Ballasts.** Use high frequency electronic ballasts to minimize flicker as lamps and ballasts wear.
- ❑ **Views.** Design a building organization and floor layout that gives each occupant adequate visual access to the outdoors and to the general organization of the building.
- ❑ **Window cleaning.** Schedule regular window cleaning to maximize the amount of daylight entering, particularly where windows are close to sources of air-borne dust, fumes, or gases that reduce the transmission of light.

Lighting Modeling Tools

For the new Blue Cross/Blue Shield building in Rochester, New York, lighting/daylighting analyses were completed using RADIANCE (a computer-based lighting modeling tool), combined with energy analyses performed using DOE-2.1E *(an energy modeling tool – see Building Energy Use, p.68).* The objective was to develop an energy efficient building envelope, while promoting good visual and thermal comfort. Since the building is dedicated mainly to computer processing, design issues relating to glare and high contrast from extensive east and west exposures are of significant concern. RADIANCE-generated renderings and numerical data can be extremely helpful in selecting the glazings, light shelves, and interior shading devices (as needed), and in identifying viable lighting and daylighting strategies. RADIANCE studies also help define interior layout, and aid in the selection of materials and colors.



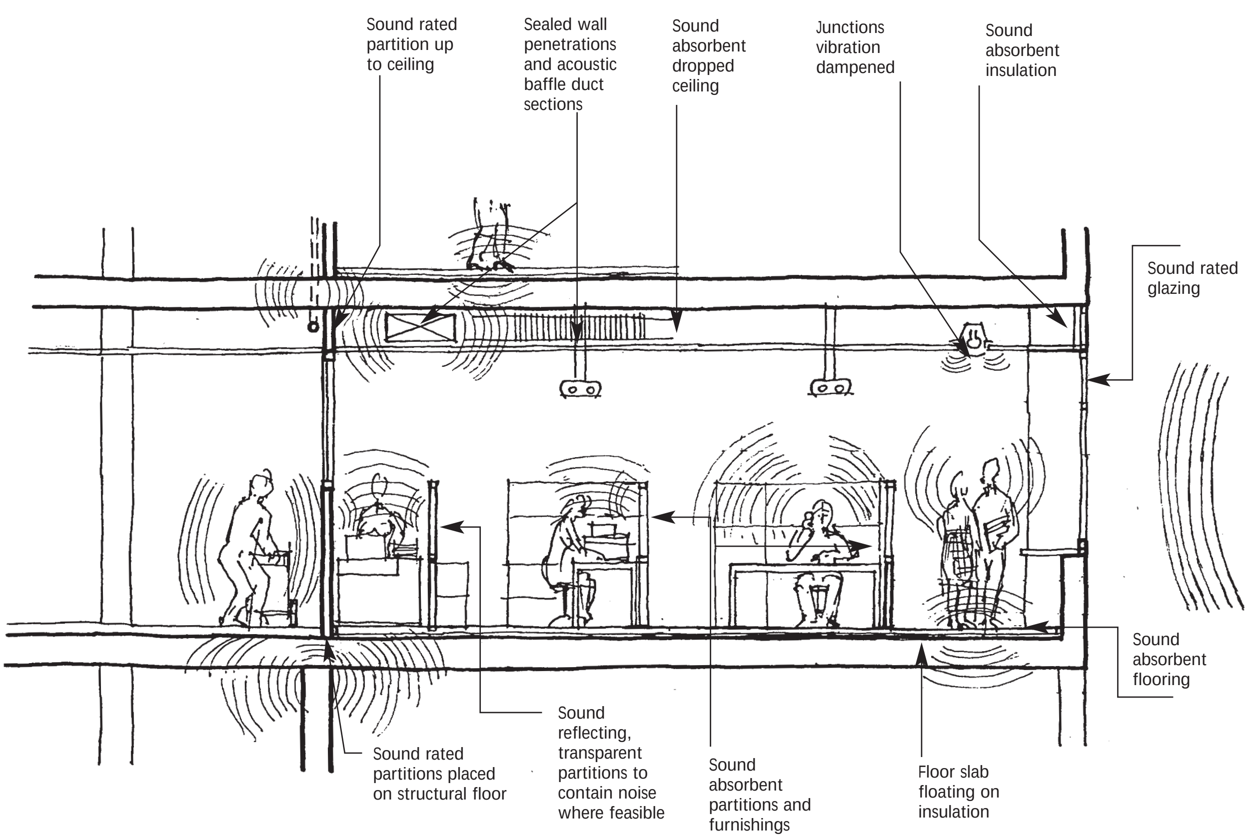
DAYLIGHTING SECTION THROUGH TYPICAL COURTROOM

New Bronx Criminal Court Complex
Daylight is reflected deep into the courtrooms in this courthouse through the use of high windows, highly reflective surfaces, and high ceilings. The top surface of the jury deliberation rooms functions as a light shelf to reflect light into the courtroom interiors.
Rafael Viñoly Architects

ACOUSTIC QUALITY

A good acoustic environment keeps noise at levels that do not interfere with activities within programmed space. The primary acoustical and speech privacy requirements in offices include the ability to speak without having conversations overheard by co-workers, and freedom from distractions caused by nearby conversations or other intruding noises. Architecturally, there are three aspects to consider: sound isolation, building services noise and vibration control, and room acoustics. Sound and vibration isolation requirements for a given space will depend on desired ambient noise levels, the extent that external sources (e.g., normal traffic, fire/ambulance/police, car alarms, air traffic) impinge upon the space, and the level of noise and vibration from nearby sources and activities. Building services that may contribute excessive noise and vibration include *HVAC systems* (air handling units, variable air volume and fan-powered terminal units, ductwork, diffusers, registers, and grilles), *plumbing* (chillers, cooling towers, boilers, pumps, pipes, valves, restrooms, laundries, and other uses) and *electrical systems* (dimmers, lighting fixtures, transformers, and generators).

Noise abatement begins with avoiding noise-generating factors, containing inevitable noise at the source, and locating sensitive spaces away from known noise sources. Sound-attenuating barriers and absorptive room surfaces must control noise transmission through the building structure and within rooms. To achieve positive acoustic quality in a room, spatial configuration and materials must be designed for appropriate resonance patterns. In overly quiet rooms, white noise can be used to mask private conversation.



Attributes of Good Acoustic Quality

Illustration: Johannes Knesl

Noise Control

Create a sound environment that is healthful, comfortable, and appropriate to intended use by controlling noise and carefully attending to the acoustic design of spaces.

Technical Strategies

- ❑ **Control Noise at the Source.**
  - ❍ Site, orient, and lay out the building such that external noise sources can be attenuated by distance or by topographic features or walls.
  - ❍ Select mechanical and plumbing devices, ductwork, and piping that generates less noise and dampens the noise generated.
  - ❍ Locate noisy mechanical equipment, office equipment, and functions away from noise-sensitive uses. Avoid locating mechanical equipment above or adjacent to noise-sensitive spaces.
  - ❍ Prevent noise transmission by absorbing noise and vibrations at the source. Consider placing vibrating equipment on isolation pads, and enclosing equipment in sound-absorbing walls, floors, and ceilings.
- ❑ **Attenuate Noise Along the Path of Transmission.**
  - ❍ Place acoustic buffers, such as corridors, lobbies, stairwells, electrical/janitorial closets, and storage rooms, between noise-producing and noise-sensitive spaces. This will alleviate the need for more complex acoustic separation solutions.
  - ❍ Prevent transmission of sound through the building structure through use of floating floor slabs and sound-insulated penetrations of walls, floors, and ceilings.
  - ❍ Prevent transmission between exterior and interior by ensuring appropriate fabrication and assembly of walls, windows, roofs, ground floor, and foundations.
  - ❍ Prevent transmission between rooms by wall, floor, and ceiling assemblies by specifying materials with appropriate sound transmission class ratings. Consider using set-off studs with sound-attenuating insulation, floating floor slabs, and sound-absorbent ceiling systems.
  - ❍ Situate mechanical room doors across from non-critical building areas. Consider the use of sound-rated acoustic doors and acoustic seals around these doors.
  - ❍ Avoid locating outside air intake or exhaust air discharge openings near windows, doors, or vents where noise can re-enter the building.
  - ❍ Consider wrapping or enclosing rectangular ducts with sound isolation materials.
  - ❍ Consider the use of sound attenuators (‘duct silencers’ or ‘sound traps’) and acoustic plenums to reduce noise in ductwork.
- ❑ **Noise Control in the Space Itself.**
  - ❍ Absorb or block excessive background noise or interfering single-source sounds in open office environments through use of resilient flooring (carpeting and tiles), ceiling (suspended ceiling tiles, absorbent ceiling geometry); and sound absorbing or reflecting partitions and furniture (chairs, desks, and shelves).
  - ❍ If appropriate conversational privacy cannot be achieved, consider using white noise.
  - ❍ In an open plan office space, offset workstations so that co-workers are not in direct line of sight or sound. Maximize distances between workstations and general office equipment. To promote sound isolation and reduce sound reflection, install partial-height freestanding walls between workstations or work groups. The walls should feature solid core construction and sound absorbing panels on both sides.
  - ❍ Achieve favorable room acoustics by configuring room geometry, positioning furnishings and furniture, and specifying appropriate surfaces. With these tools, achieve a level of room resonance quality that supports the programmed uses, such as face-to-face communication, conference, or audio-visual presentations.

Queens Criminal Court Complex

In the DDC-administered design of the Queens Criminal Court Complex, the layout arranged existing and planned buildings to create interior courtyards. The design provided secure open spaces for light, air, and views while shielding the program spaces from noise generated by the Van Wyck Expressway and Queens Boulevard, which border the site. Interior acoustic requirements were programmed for each space, with values set for such characteristics as noise criteria, resonance properties, and partition and door types.

▶ **Benefits**

$\$P_F$

Acoustic comfort can contribute to occupant comfort and sense of well-being. It can reduce distraction and thus may be linked to improved worker performance.

Controllability of Systems

Benefits ◀

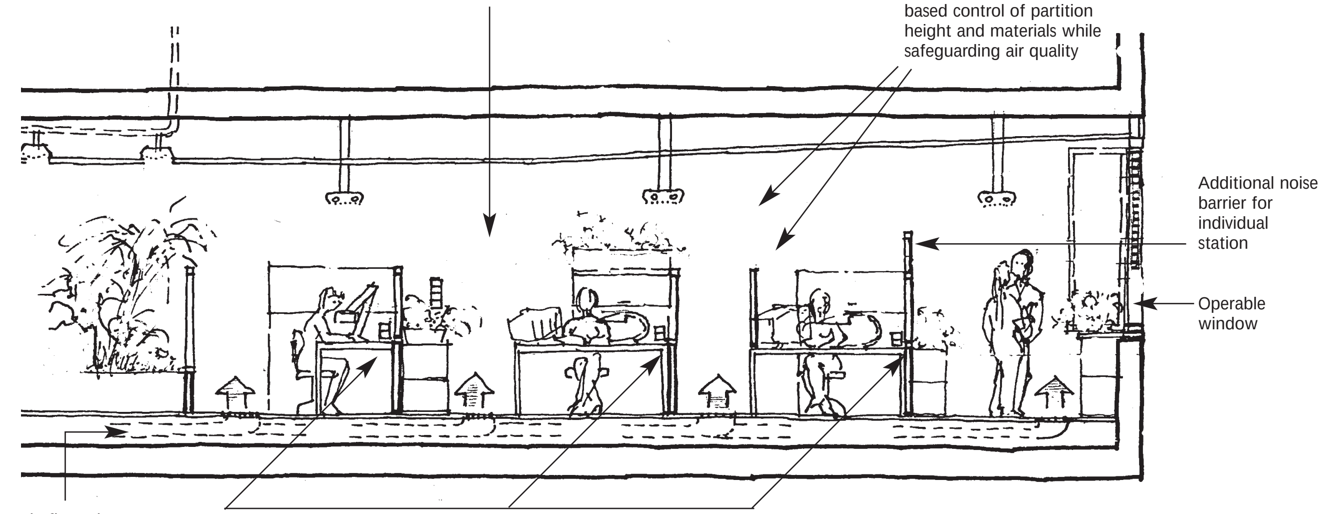
P_F

Some measure of personal control over one's immediate surroundings creates a more positive outlook toward the work environment and may contribute to individual comfort and health. There may be additional links to improved worker productivity.

To achieve a healthy and comfortable environment, it is critical to ensure that user groups and facility maintenance staff can knowledgeably operate the building systems and equipment. As much control as possible should be given to individual users, without compromising the effectiveness and efficient control of the overall system.

Technical Strategies

- ❑ **Simplification.** Provide building users and maintenance staff with a level of control over automated building systems that is appropriate to their level of technical expertise.
- ❑ **Personal control.** Build in a capacity for personal control over the immediate indoor environment. Assure that the global indoor environment is within acceptable limits by bringing air supply points and controls for air quality as close to individual workstations as possible. Balance control system advantages against energy use and maintainability. The objective is to enable users to control the lighting level and distribution in their area using task and accent lighting, dimmer switches, and daylighting controls such as individually operable blinds.



Controllability of Systems

Illustration: Johannes Knesl

Indoor Environment

Building Integration

Site Design. Appropriate siting and use of solid landscape elements helps control noise.

Building Energy Use. Thermal comfort is improved by reducing drafts and radiant heat loss/gain with energy improvements such as thermally-efficient windows, increased thermal insulation, and measures to control infiltration losses/gains.

Building Energy Use. Building energy use may increase as air quality measures are implemented. Thermal comfort of occupants depends on air speed, delivery method, temperature and humidity – all of which are controlled by the building's mechanical system.

Building Energy Use. To minimize heating and cooling loads, daylighting must be controlled by selecting the size, location and orientation of building openings, and specifying appropriate glazing materials and shading devices. A properly designed daylighting system reduces energy costs.

Building Energy Use. Lighting systems with light sources and distributions capable of generating high visual quality may require more energy than lower quality systems.

Material and Product Selection. Indoor air quality benefits from chemically benign or inert construction and finish materials, products, and equipment.

Material and Product Selection. Materials and assemblies selected for their acoustic properties also need to perform well by meeting high performance criteria for indoor air quality.

Commissioning. Commissioning HVAC systems supports good indoor air quality.

Operations and Maintenance. Careful selection and use of non-toxic and non-irritating chemicals in housekeeping and pest control is crucial to achieving favorable, long term indoor air quality.

PERFORMANCE GOALS FOR INDOOR AIR QUALITY

Indoor Environment:

Indoor Air Quality

LEVEL 1

- ❑ Conform with ASHRAE 62-1989 for ventilation-related indoor air quality issues. Be sure to compare NYC Building Code ventilation index requirements (or other governing code regulations) with provisions contained in the consensus standards of ASHRAE 62-1989. Follow the more stringent requirements in critical spaces as identified in the Environmental Programming Matrix.
- ❑ Conform with ASHRAE Standard 55-1992 for thermal comfort and compare with governing client agency requirements and applicable state codes.
- ❑ Specify that the building be smoke-free, with no tobacco smoking permitted indoors, or restrict smoking to enclosed and depressurized smoking rooms from which air is exhausted separately to the outdoors.
- ❑ For renovation, comply with SMACNA's *IAQ Guidelines for Occupied Buildings Under Construction* and other applicable City guidelines such as those developed for school facilities (refer to Construction Administration section). Measures should include: (1) protection of HVAC equipment from dust and odors (where possible, the entire systems should be taken down during heavy construction or demolition; filters with 60 to 80% dust spot efficiency should be used; and supply side diffusers, VAV boxes, and ducts should be shut down and sealed); (2) source control (substituting low VOC-emitting products, modifying equipment operation, changing work practices, providing local exhaust and/or air cleaning and covering, or sealing known sources); (3) pathway interruption (e.g., de-pressurize work area or pressurize the occupied space, erect barriers to contain the construction area, relocate pollutant sources, or temporarily seal the building); (4) housekeeping (dust suppression, covering contents in work area, protecting porous materials from moisture); and (5) scheduling to avoid occupied periods, providing 48 hours of continuous ventilation after final installation and cleaning, and using 'buffer zone' to protect building occupants).
- ❑ Implement a "Building Air Quality Action Plan" as defined by the U.S. Environmental Protection Agency (http://www.epa.gov/iaq/base/actionpl.html).

LEVEL 2

- ❑ Meet Level 1 requirements and implement the "Best Practices for Maintaining IEQ" measures listed in the Indoor Environmental Quality appendix to the 1999 Version of the International Performance Measurement and Verification Protocol (download at no cost from www.ipmvp.org – select 'download,' enter contact information (optional), and download IEQ Appendix as a .pdf file).

PERFORMANCE GOALS FOR VISUAL QUALITY

Indoor Environment:

Visual Quality

LEVEL 1

- ❑ Comply with IESNA standards in consultation with client-specified lighting levels. Energy efficient lighting systems set for appropriate luminance ratios (as established by IESNA), achieve a balance of vertical to horizontal illuminance, and are effective in controlling glare and rendering color. Flicker and interference are also kept to a minimum. Lighting controls shall meet or exceed the control requirements of the New York State Energy Conservation Construction Code. They shall provide proper control through use of manual or automatic switching, timers, occupancy sensors, dimmers or photoelectric controls. They should also achieve a maintenance of high color rendering index, and use electronic ballasts, compact fluorescents, parabolic fluorescents, and halogens insofar as is practicable.
- ❑ Ensure that the interior layout provides adequate visual access to exterior views.
- ❑ Specify visible light transmission for glazing at 50% or higher for most spaces. Lower visible light transmission could be appropriate for specific uses (such as intensive computer work), or for particular orientations – particularly west.[60]
- ❑ Provide a design that yields a minimum daylight factor[61] of 1.5% on the work plane at a depth of 15 ft. from the building exterior for all applicable perimeter spaces. Control quality issues such as glare, veiling reflections, and contrast so that daylight does not hinder activities scheduled for the space. Achieve IESNA footcandle requirements for scheduled use through effective integration of daylight into the lighting design.

LEVEL 2

- ❑ Provide a design that yields daylighting availability to a depth of 30 ft. (with a minimum daylight factor of 3.0% on the work plane at a depth of 15 ft.) through use of redirecting devices such as light shelves. Control quality issues such as glare, veiling reflections, and contrast so that daylight does not hinder activities scheduled for the space. Achieve IESNA footcandle requirements for scheduled use through integration of daylighting into the overall lighting design.

60. The 50% transmission criterion includes all clear glass, most low emissivity (low-e) coated glass in single, double or triple glazed units, and many lightly tinted glass units.
61. The daylight factor is the percentage of light available inside a building at a given point, as compared to the illumination level available at that time outdoors on a horizontal surface under overcast sky conditions.

PERFORMANCE GOALS FOR ACOUSTIC ENVIRONMENT

Indoor Environment:

Acoustic Environment

LEVEL 1

- ❑ In the Environmental Programming Matrix, identify sound-critical spaces[62] and consult with an authority in acoustic layout to determine the appropriate response.
- ❑ Internally generated noise from mechanical systems, plumbing, lighting, and interior activities are to be reduced to a maximum noise criteria (NC) of 35. Externally generated noise is to be isolated from occupied zones to ensure that internal NC levels do not exceed 35 (i.e., from building-related activities such as trash collection/ compaction, exterior maintenance, traffic, and construction).[63]
- ❑ In areas of high ambient noise (traffic, aircraft, industry), windows are to be rated at an STC[64] of 40 or better. In other areas, windows should achieve an STC of 35 or better.

PERFORMANCE GOALS FOR CONTROLLABILITY OF SYSTEMS

Indoor Environment:

Controllability of Systems

LEVEL 1

- ❑ Sensors and controls are to achieve ASHRAE 55a-1995 requirements for comfort.
- ❑ Proper function of control systems is to be verified through commissioning per ASHRAE Guideline 1-1996, *Guideline for Commissioning of HVAC Systems*, and preventive maintenance to be performed in accordance with ASHRAE Guideline 4-1993, *Preparation of Operating and Maintenance Documentation for Building Systems*.

Tools for Indoor Air Quality

- ➤ Engineering calculations should be performed based on ASHRAE Handbook of Fundamentals and Standards *(see References).*
- ➤ Air infiltration rates, airflows between zones, and indoor pollutant concentrations can be evaluated using direct investigation, testing equipment, measurement of carbon dioxide concentrations, and tracer gas testing.

Tools for Visual Quality

- ➤ Use physical models with adequate simulation of site conditions and interior surfaces to assess daylight quality throughout the design process. Be sure to perform computer-based modeling (such as RADIANCE or Lightscape) of the lighting environment at different times of the day to calculate illuminance and simulate the resulting visual quality. Where use of daylighting features such as light shelves and other reflective systems has been deemed effective, incorporate them into the design.

62. 'Sound-critical' spaces have programmed usage that requires specific attention to sound isolation, building systems noise control, or room acoustic design.
63. The noise criteria (NC) is a rating of the noise level of an interior space. In new construction, an NC level is set based on the room type and intended function. The NC level serves as a goal in the design of sound isolation construction and attenuation of mechanical system noise. In renovation projects, the NC rating can be established by taking octave-band noise level measurements and plotting them against a series of NC curve spectra (sound level energy versus frequency curves). The NC value is determined by the lowest curve that lies completely above the measured spectrum values.
64. The sound transmission class (STC) is a rating of the sound isolation performance of a partition, door or window. A rating of STC 40 can typically be met by double glazing (refer to manufacturer's data).

Deliverables

Pre-Preliminary and Schematic Design.

- **Indoor Air Quality.** The Environmental Programming Matrix will designate IAQ performance goals in general, and specifically, for higher performance in strategic spaces, e.g. outside air quantities based on occupancy and use of the space.
- **Visual Quality.** The Environmental Programming Matrix will designate lighting standards and criteria that are to be included in the High Performance Report. Include expected lighting standards in drawings and justify any occupied workspaces without adequate access to daylight. Where advisable due to sensitive uses or unusual building configurations, produce a 3-D working model to simulate daylighting conditions. The model should adequately represent site conditions and interior surfaces. Incorporate the results into the High Performance Report.
- **Acoustic Quality.** The Environmental Programming Matrix will designate acoustic design criteria for each space. Indicate location of sensitive uses and noise sources therein.
- **Controllability of Systems.** The Environmental Matrix will outline a strategy for the nature and extent of user control over the systems responsible for indoor environmental quality.

Design Development.

- **Indoor Air Quality.** Verification of the goals established in the previous design phase as to items such as amount of cubic feet per minute and outside air percentages, filters, anticipated performance in terms of comfort, and anticipated levels of carbon dioxide and pollution.
- **Visual Quality.** Verify that previously established criteria are being met. Update 3-D model of lighting quality. Where advisable due to sensitive uses or building configuration, provide computer-based lighting calculations and simulated views of the indoor environment at typical and critical locations to demonstrate illuminances and their distribution. Incorporate the results into the High Performance Report. Verify daylighting conditions and effectiveness of combined use of daylighting and electrical lighting by calculation.
- **Acoustic Quality.** Document sound transmission characteristics of walls, glazing, floors, ceilings, mechanical, and plumbing systems to demonstrate attainment of the acoustic design criteria. For spaces such as auditoriums, that are especially sensitive, provide a detailed acoustic performance study.
- **Controllability of Systems.** Verify attainment of the user controllability goals and update the High Performance Report accordingly.

Final Design.

- **Indoor Air Quality.** Update information supplied during Design Development and document attainment of required design characteristics by showing equipment specifications and appropriate detailing of materials assemblies.
- **Visual Quality.** Document attainment of required visual environment characteristics through appropriate detailing of materials assemblies, specified material reflectances, etc.
- **Acoustic Quality.** Document attainment of required acoustic design characteristics by appropriate detailing of materials assemblies, construction ratings, and furnishings.

Construction.

- **Indoor Air Quality.** See Commissioning chapter for guidance in developing an IAQ plan during construction, and for functional testing procedures(s).
- **Acoustic Quality.** Verify attainment of acoustic design criteria as part of Commissioning of the building systems.

Occupancy Phase.

Mechanical/ Electrical Systems Instruction Manuals as described in Section 16000 of the Project Specifications are to be provided by the trade contractors for the following systems:

- Heating, ventilating and air conditioning (HVAC) system
- Hydronic distribution system
- Air handling/distribution system
- Glazing maintenance/cleaning
- Kitchen HVAC system
- Fire protection system
- Electrical systems, fire alarm, security and uninterrupted power supply systems

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Various articles on case studies and technology available at http://www.arc.cmu.edu/cbpd/

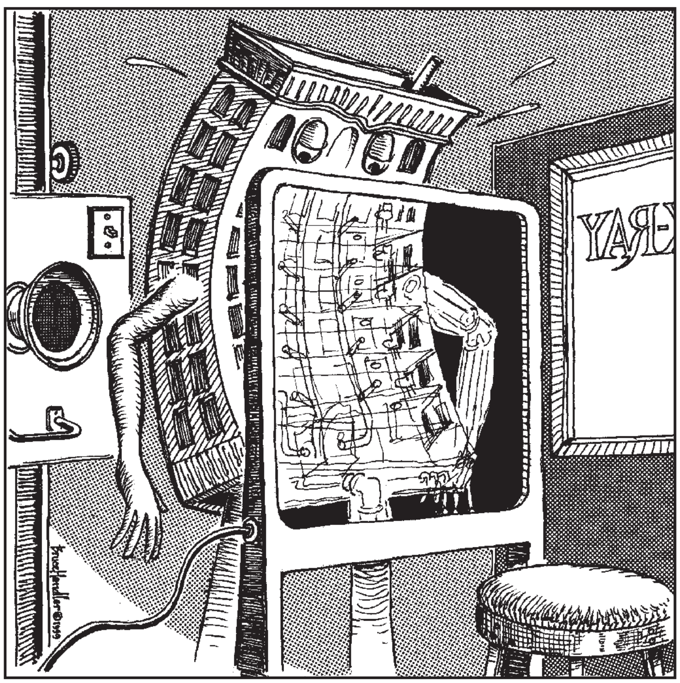


Illustration: Bruce Hendler

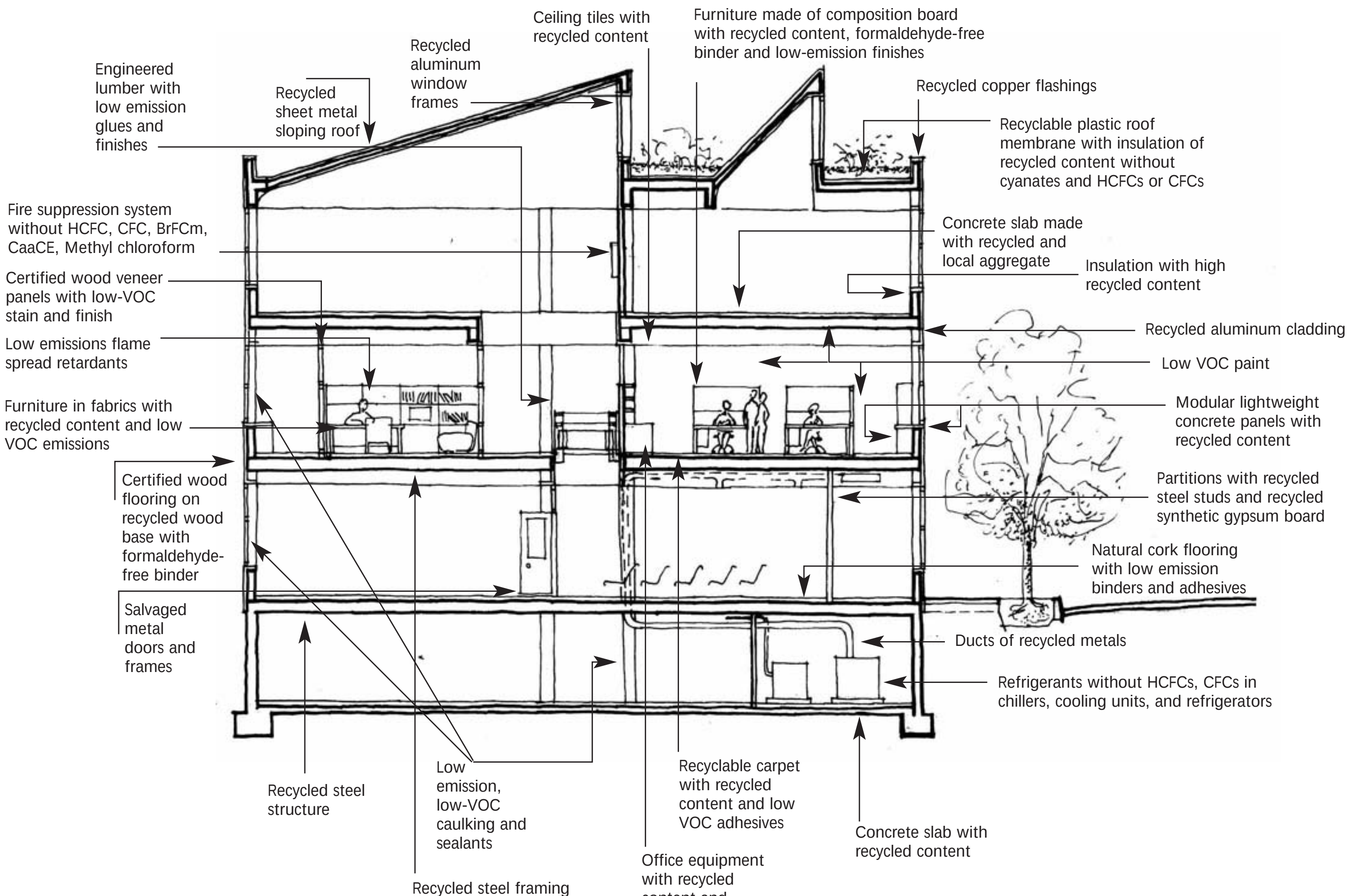
Material and Product Selection

Selecting materials and products for high performance buildings involves consideration of environmental and health issues in addition to more traditional criteria such as cost, durability, performance, and aesthetics. While methods for evaluating products based on these criteria are still evolving, the number of available building products with improved environmental and health characteristics has been steadily increasing. Markets are responding to meet the demands of government, businesses, and consumers who are increasingly aware of health and environmental concerns.

Because of the complexities surrounding evaluation of appropriate materials, consultants should have a working familiarity with the key health and environmental issues associated with specific material types. This dynamic and growing field includes new concepts in materials assessment such as embodied energy and product life cycle assessment.

Material and Product Selection

ENVIRONMENTALLY PREFERABLE MATERIALS



High Performance Material and Product Selection
Illustration: Johnannes Knesl

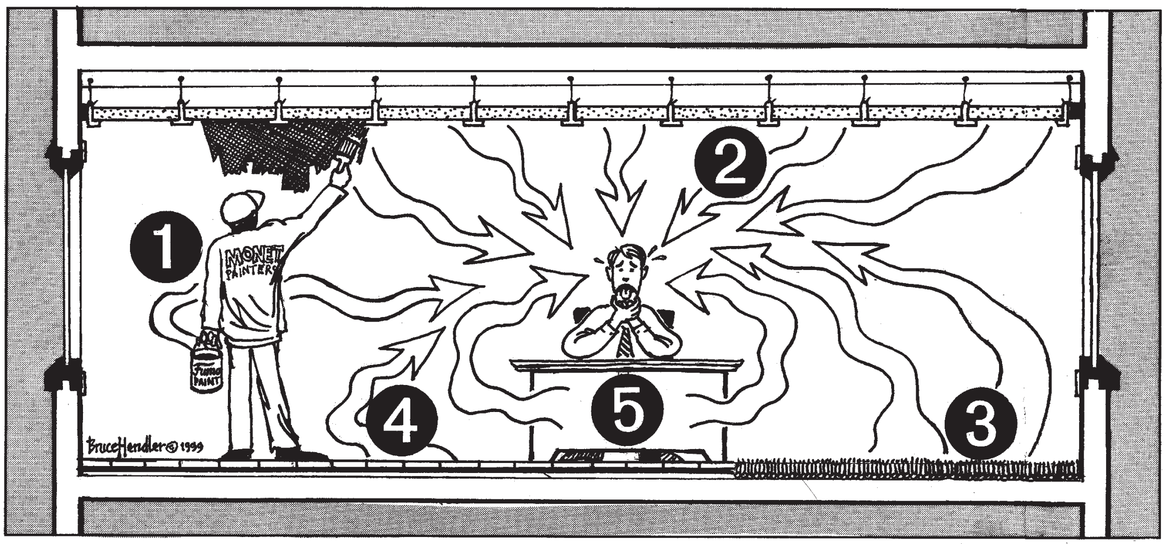
Most environmentally preferable[65] materials include one or more of the following characteristics:

1. They benefit the building occupants and management immediately and over the life of the building. Examples include materials that:
   - Have low or no chemical emissions that can lead to poor indoor air quality;
   - do not contain highly toxic compounds; and
   - are durable and have low maintenance requirements.
2. They are resource efficient. Examples include materials that:
   - Have recycled content (post-consumer and pre-consumer);
   - are easily reused (whole or through disassembly); and
   - are easily recycled (preferably in closed-loop recycling systems).
3. They have far-reaching, global impacts. Examples include materials that:
   - Contain no CFCs, HCFCs, or other ozone depleting substances;
   - are obtained from sustainable harvesting practices (such as certified wood products);
   - are obtained from local resources and manufacturers;
   - have low embodied energy;
   - are derived from renewable resources; and
   - are biodegradable when disposed.

65. Environmentally preferable: products or services that have a lesser or reduced effect on human health and the environment when compared with competing products or services that serve the same purpose. This comparison may consider raw materials acquisition, production, manufacturing, packaging, distribution, reuse, operation, maintenance, or disposal of the product or service. Executive Order 13101 September 14, 1998.

Selection for a Healthy Indoor Environment

Overall indoor air quality goals can be achieved by specifying and installing benign, or 'healthy' building materials. These include materials and products that exhibit limited or no 'off-gassing' tendencies, have minimal or no toxic properties, do not shed dust and fiber, and do not absorb pollutants that are later released, potentially generating complaints among building users/occupants.[66]



Sources of offgassing in building materials typically include:
❶ paints, ❷ ceiling tiles, ❸ carpeting,❹ VCT floor tiles, and ❺ manufactured wood products.

Technical Strategies

- ❑ **Prioritize sensitive program areas.** Identify and prioritize spaces where material selection issues are of particular concern based on intended occupancy. Since children and the elderly are especially susceptible to indoor air pollutants, spaces requiring added diligence may include client and visitor-occupied areas of health care facilities, day care centers, senior citizen centers, schools, libraries, and other community buildings.
- ❑ **Product consensus standards.** Select products based on available consensus standards (developed by government agencies, environmental certification services, or trade organizations) that define emission limits, or address other health/toxicity issues relating to specific material types. *(See page 94).*
- ❑ **Specification criteria.** Provide specification criteria for 'healthy' materials and for appropriate installation methods. Criteria can be developed from the product consensus standards listed here, and from additional material guidelines *(see Tools and References).*
- ❑ **MSDS/manufacturer certifications.** For materials that are deemed critical to the project and for which standards or other references do not exist, obtain and review material safety data sheets (MSDSs) and/or manufacturers' certifications or test data. Contact manufacturers for clarification as needed. Review by experienced indoor air quality professionals may be justified for particularly critical materials or sensitive spaces.
- ❑ **Field approval.** Review and approve contractor requests for product substitutions to ensure that the indoor air quality criteria defined in the specifications have not been compromised. Require MSDSs and other certifications for any product substitutions affecting critical items. Require justification from contractor for substitutions that do not meet environmental performance criteria.

▶ **Benefits**

$\$P_F$
An indoor environment that contributes to the health and well-being of users/occupants can help reduce absenteeism. The potential also exists for increased performance and productivity.

$\$P_F$
Healthier working conditions for builders, installers, and custodians.

$\$D_S$
Expansion of markets for environmentally preferable products.

E_S
Selection of healthy materials may also provide external environmental benefits, such as reduced smog formation (VOCs combine with oxides of nitrogen to form ozone, the principal component of smog) or reduced production and release of toxic compounds.

66. Some building materials and assembled products release pollutants, including volatile organic compounds (VOCs), commonly found in paints, stains, cleaning products, adhesives, manufactured wood products, carpets, and acoustical ceiling tiles. Formaldehyde is one of the best known VOCs, and is found in many building products, including manufactured wood products made with urea-formaldehyde binders. Additionally, fibers and particles found in insulation, in return air plenums above acoustical ceilings (e.g., from ceiling tiles or fire proofing in the plenum) and in fiberglass duct board can potentially be shed into the building's air. Without careful selection, installation, and maintenance, such materials can contribute to poor indoor air quality (see Indoor Environment chapter).

Product Consensus Standards for Emission Limits

Readily available standards and criteria that are current at the time of this printing are listed below. Consultants should ensure they have the most current standard as well as any others that may become available.

Engineered Wood Products

Referenced Standards: ANSI A208.1-1993 (particleboard); ANSI "PBU," "D2" or "D3" (particleboard flooring); ANSI A208.2-1994 (medium density fiberboard); ANSI/HPVA HP-1-1994 (hardwood plywood)

Agency: American National Standards Institute

Notes: Defines maximum allowable formaldehyde emissions based on ASTM test procedures.

Availability: http://web.ansi.org/default_js.htm, documents can be ordered.

Paints

Referenced Standard: Green Seal Paints (GS-11)
Agency: Green Seal, Inc. (Third-Party Certification Service)
Notes: Defines VOC limits and chemical component limitations for interior and exterior topcoat paints.
Availability: http://www.greenseal.org

Construction Adhesives

Referenced Standard: South Coast Rule #1168 (Adhesive Applications)
Agency: South Coast Air Quality Management District (California)
Notes: Defines VOC limits for adhesives and primers. Referenced in the US Green Building Council's LEED Building™ Rating System.
Availability: Internet Address: http://www.aqmd.gov/rules/html/r1168.html

Architectural Sealants

Referenced Standard: Regulation 8, Rule 51 (Adhesive and Sealant Products)
Agency: Bay Area Air Quality Management District (California)
Notes: Defines VOC limits for sealants and sealant primers. Referenced in the US Green Building Council's LEED Building™ Rating System
Availability: Internet Address: http://www.baaqmd.gov/regs/rulereg.htm

Carpets

Referenced Standard: Carpet and Rug Institute (CRI) Indoor Air Quality Carpet Testing Program
Agency: Carpet and Rug Institute, Dalton, GA (trade organization)
Notes: Defines maximum allowable emissions of total VOCs, formaldehyde, and other specific compounds for carpets, carpet adhesives, and carpet cushions.
Availability: Internet Address: http://www.carpet-rug.com/

Systems Furniture

Referenced Standard: State of Washington Department of General Administration, East Campus Plus Program – Indoor Air Quality Compliance Tables
Agency: State of Washington Department of General Administration
Notes: Defines maximum allowable emissions of total VOCs, formaldehyde, and total particulates for systems furniture.
Availability: Limited availability of tables on request from: State of Washington Department of General Administration; Division of Engineering and Architectural Services; General Administration Building, P.O.Box 41012, Olympia, WA 98504-1012

The New Children's Center

In the design of the New Children's Center for the Administration for Children's Services, the team was particularly concerned about providing an improved indoor environment for the Center's young clientele and for its staff. With this in mind, the project team selected materials with benign properties to minimize any negative impact on indoor air quality. As a result, the project is using rubber flooring and cork flooring with low-emission adhesives, and paints and sealants with low-VOC content in lieu of conventional products. Because of its tendency to act as a 'sink' for possible contaminants and allergens, carpeting will not be used at all in this application.

New York State Department of Environmental Conservation

Material recommendations for the New York State Department of Environmental Conservation headquarters in Albany, New York included carpet tiles with low VOC backings and adhesives, stone flooring from local quarries, low-emission wall coverings made from spun glass or paper/cotton, low-VOC or no-VOC paints, and millwork constructed using wheat-straw particle board, or non-formaldehyde MDF board (medium density fiberboard).

Selection for Resource Efficiency

Resource efficiency can be achieved through conscientious design strategies, and by selecting environmentally preferable building materials. These measures can conserve natural resources while minimizing the generation of waste and pollution during construction. The hierarchy of 'reduce, reuse, recycle' can serve as a guideline for decisions relating to resource efficiency.

Technical Strategies

- ❑ **Set resource efficiency goals.** Identify the major products and materials that will be used throughout the building, and prioritize opportunities for applying resource efficiency strategies.
- ❑ **Reduce (waste prevention).**
  - Efficient design and detailing helps reduce material usage and waste generation. Eliminate unnecessary finishes and other products in areas where they are not required.
  - To the extent possible, use modular materials and base designs on modular sizing as appropriate.
  - Select products for durability. This reduces replacement costs, occupant disruption, and waste disposal.
- ❑ **Reuse.**
  - Incorporate salvaged or refurbished materials whenever possible. Early in the process, identify materials from existing buildings (e.g., doors, brick) that can be re-used and stockpiled in architectural salvage. Identify local suppliers of additional reusable material *(see References for information on the New York City-run salvage program).*
  - Encourage on-site reuse of scrap material.
  - Consider construction assemblies that allow for disassembly of materials at the end of their useful life. This encourages the reuse of valuable materials and may simplify renovations and repairs.
- ❑ **Recycle (products with recycled content).**[67]
  - Conform to existing product consensus standards for resource efficient materials. These standards have been developed by government agencies, environmental certification services, or trade organizations to support selection of environmentally preferable materials. The criteria are current at the time of this writing, but are subject to change over time. Consultants should use the most current standards as they become available.

<u>**Products Containing Recycled Content**</u>

Referenced Standards: The U.S. EPA has identified (and continually updates) a listing of products with recycled content in its Comprehensive Procurement Guidelines (CPGs). The recommended recycled content levels for each type of product are listed in the related Recycled Materials Advisory Notices (RMANs). Suitable products for construction and renovation projects can be found under the following EPA categories: Construction, Parks and Recreation, Landscaping, Transportation, and Miscellaneous. Products designated prior to October 1998 include: Structural Fiberboard, Laminated Paperboard, Rock Wool

▶ **Benefits**

$\$O_F$
Facility operational savings are achieved through use of more durable materials that need to be replaced less often.

$\$O_M$
Municipal operational savings are achieved by generating less waste, reusing materials, and avoiding hazardous materials – all of which reduces disposal costs.

$\$D_S$
Expands markets for environ-mentally preferable products.

E_S
Environmental benefits attained through reduced consumption and waste; conservation of natural resources; avoided toxic substances.

67. 'Recycled content' often includes various combinations of pre-consumer and post-consumer material. Post-consumer material is a material or finished product that has served its intended use and has been discarded for disposal or recovery, having completed its life as a consumer item. Pre-consumer material is material diverted from the waste stream following an industrial process, excluding reutilization of materials such as rework, regrind, or scrap generated during a given process and capable of being reclaimed within the same process. Synonyms include post-industrial and secondary material.

Insulation, Fiberglass Insulation, Cellulose Insulation, Perlite Composite Board Insulation, Plastic Rigid Foam Insulation, Foam-in-Place Insulation, Glass-Fiber Reinforced Insulation, Phenolic Rigid Foam Insulation, Floor Tiles, Patio Blocks, Polyester Carpet Fiber Face, Latex Paint, Shower and Restroom Dividers, Parking Stops, Plastic Fencing, Playground Surfaces, Running Tracks, Garden and Soaker Hoses, Lawn and Garden Edging, and Yard Trimming Compost.

EPA periodically revises its material designations and recycled content levels. Thus, the design team (and materials specifiers) should refer to the most recent standards. CPG/RMAN I and II were current as of December, 1998. EPA proposed 19 additional products in CPG/RMAN III in August, 1998 and is currently working on CPG/RMAN IV.

Agency: U.S. EPA Buy Recycled Series, U.S. Environmental Protection Agency.

Notes: Defines recommended percentages of recycled content in various products.

Availability: U.S. EPA Buy Recycled Series is published annually.
Internet Address: http://www.epa.gov/cpg

Concrete with Flyash

Referenced Standards: ASTM Standard C-618

Agency: American Society for Testing and Materials

Notes: Defines technical standards for the use of flyash in concrete, including maximum carbon content.

Availability: Internet Address: http://www.astm.org/, documents can be ordered.

- ❑ **Manufacturer or third-party certification.** Check for third-party certification of manufacturer claims and determine whether self-certification is required for specific items.
- ❑ **Specification criteria.** Provide specification criteria for resource efficient materials selection and procedures for appropriate installation. Criteria can be developed using product consensus standards and other material guidelines *(see Tools and References).*
- ❑ **Field approvals.** Review and approve contractor requests for product substitutions to ensure that the resource efficiency criteria defined in the specifications have not been compromised. Require MSDSs and other certifications for any product substitutions affecting critical items.

Flue-Gas Desulfurization Gypsum

Flue-gas desulfurization (FGD) gypsum is a recycled material that's widely used in the United States today. FGD gypsum is created as a by-product of air pollution control processes at power plants designed to help remove sulfur oxides (SO_X), produced by the burning of fossil fuels. More and more power plants are being required to control SO_X emissions, based on their role in acid rain formation. The chemicals used in the desulfurization process are combined with substances in the flue gases to produce a high quality synthetic gypsum that can then be used in construction. The Gypsum Association reports that FGD gypsum is a cost-effective feedstock for gypsum board, and that over one million tons were used in 1996. However, supplies are estimated to increase to 11 million tons per year as Phase II of the Clean Air Act is implemented. Competitively priced gypsum board containing 10% to 100% of this pre-consumer recycled material is already on the market. As no EPA standard currently exists, manufacturers must provide certifications of recycled content to specifiers and contractors. Although manufacturers may include recycled facing paper in their percentages of recycled content, no specification is necessary as all such facing paper contains 100% recycled fiber.

Selection for External Environmental Benefit

The selection and use of environmentally preferable materials yields benefits that exceed the scope of the building itself. Products produced and deployed in an environmentally responsible manner help reduce local, regional, and global pollution while encouraging sustainable stewardship of resources. For example, global benefits accrue from specifying sustainably harvested, certified wood products, and from avoiding the use of ozone-depleting compounds in foam products, refrigeration and fire suppression systems.

▶ **Benefits**

$\$D_S$
Expands markets for environmentally preferable products.

E_S
Conserves natural resources; protects biodiversity; reduces soil, water, and air pollution.

Technical Strategies

❑ **Sustainable or renewable resources.** Conform to existing product consensus standards when selecting independently certified materials derived from renewable resources (such as wood products). The criteria in the following standard were current at the time of this writing but subject to change over time. Use the most current standard as well as any others that may become available.

Certified Wood from Well-Managed Forests

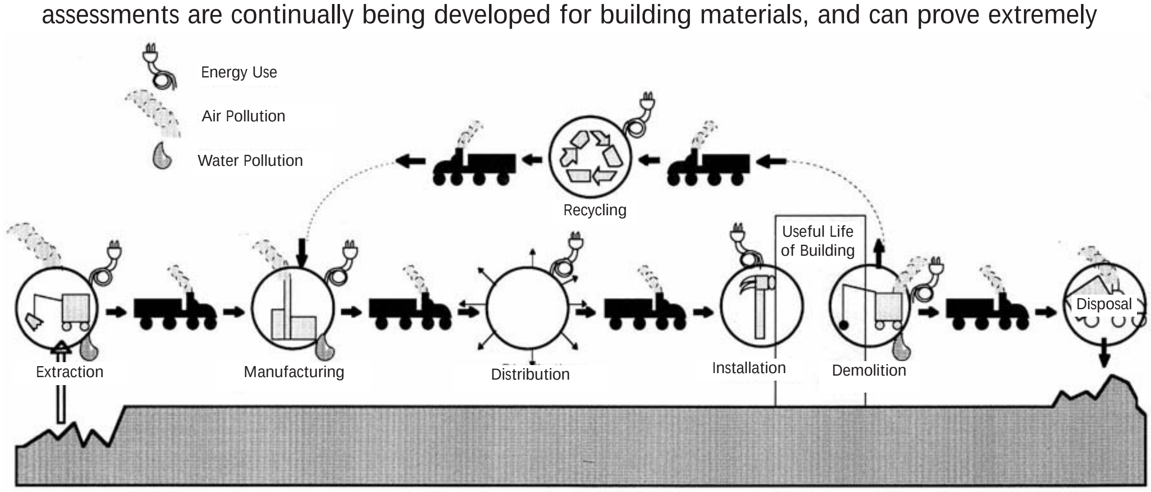
Referenced Standards: Principles and Criteria for Forest Stewardship
Agency: Forest Stewardship Council, A.C., (third party certification service).
Notes: Defines standards for well-managed forestry operations and accredits other certification bodies *(in the U.S. these include SmartWood and the Scientific Certification Systems Forest Conservation Program—see Tools).*
Availability: Internet Address: http://www.fscoax.org/

❑ **Ozone depleting substances.** Select foam products (such as insulation), refrigeration and fire suppression systems that do not contain CFCs, HCFCs, bromofluorocarbons (halons), methyl chloroform, or carbon tetrachloride.

❑ **Locally obtained products and materials.** Wherever possible, obtain materials and products from local resources and manufacturers, thereby minimizing energy use and pollution associated with transportation.

❑ **Product life cycle cost.** Consider life cycle cost[68] when selecting products. It is often the case that durable, low-maintenance products are less expensive over time than products with an attractive first cost that then require frequent maintenance and replacement.

❑ **Product life cycle assessment.** When available, use life cycle assessments[69] for high priority materials identified during the development of resource efficiency goals. These 'cradle-to-grave' assessments are continually being developed for building materials, and can prove extremely



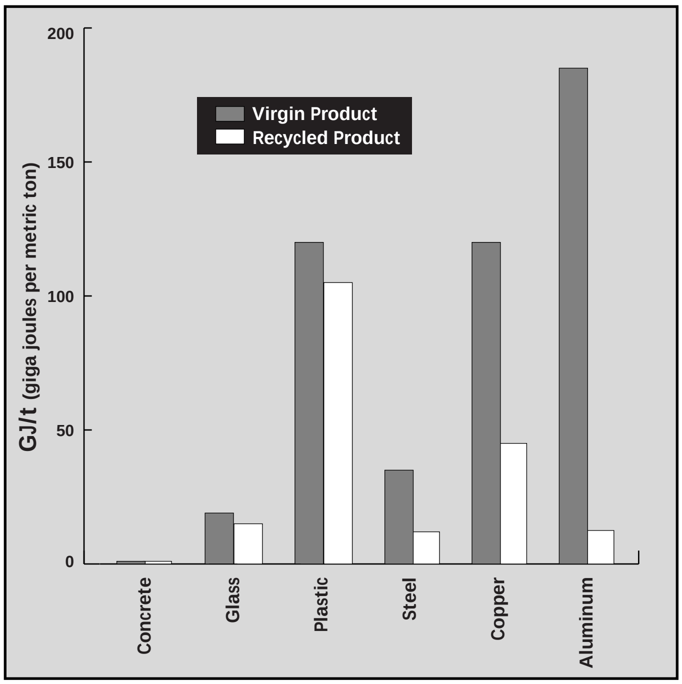
Product Life Cycle Assessment
The cost of a building material must be viewed through a times lens, from extraction of the raw material from the earth through the various stages of production, installation, and demolition, to its final resting place in a landfill. Each stage in the process of production and removal consumes energy and adds pollutants to the air and water. Each stage also requires transportation, which further contributes to pollution and the consumption of fossil fuels. When raw materials are extracted, the earth is depleted, and when they are disposed of in landfills the process also negatively impacts the earth. Recycling avoids these adverse consequences by putting materials back into production and use.
Illustration: Carol Latman

68. 'Life cycle cost' means the amortized annual cost of a product, including capital costs, installation costs, operating costs, maintenance costs, and disposal costs discounted over the lifetime of the product.
69. 'Life cycle assessment' means the comprehensive examination of a product's environmental and economic aspects and potential impacts throughout its lifetime, including raw material extraction, transportation, manufacturing, use, and disposal. Executive Order 13101 September 14, 1998.

helpful when specifying sustainable, resource efficient products and systems. Specifiers must consider the environmental impacts associated with all stages of product development, use, and disposal *(see diagram)*, as well as 'embodied energy' (the energy used for production and transportation) as important criteria in product selection *(see diagram).*

- ❑ **Specification criteria.** Provide specification criteria for environmentally preferable materials selection and for appropriate methods of installation. Criteria can be developed using product consensus standards and other material guidelines *(see Tools and References)*.
- ❑ **Field approvals.** Review and approve contractor requests for product substitutions to ensure that environmental criteria defined in the specifications have not been compromised. Require MSDSs and other certifications for any product substitutions affecting critical items.

Embodied Energy of Building Materials



Embodied Energy
The 'embodied energy' of a material represents the energy expended in its production, such as the energy for extraction of the raw material, and energy used in transportation and manufacturing. This chart compares embodied energy of virgin materials versus recycled materials. When a material is recycled embodied energy is lower, because the energy necessary for extraction is eliminated, and energy consumed for manufacturing is somewhat reduced (depending on the material). For example, this chart shows that the embodied energy for virgin concrete and recycled concrete is virtually the same, whereas the production of aluminum is highly energy intensive, though the embodied energy of recycled aluminum is much lower.

Source: Penttala, Vesa. "Concrete and Sustainable Development," *ACI Materials Journal*, Sept-Oct, 1997, page 415.

Building Integration

Building Energy Use. Consider the performance of materials from the perspective of how they will impact the building's energy use (e.g., insulation, windows, and doors).

Construction Administration. Whenever possible, reuse materials from the site.

Operations and Maintenance. Select materials based on the extent to which they will contribute to efficient maintenance protocols. The juxtaposition of many different materials can result in inefficient maintenance practices and additional costs (more time and/or cleaning products required).

PERFORMANCE GOALS

Material and Product Selection

LEVEL 1

- ❑ Implement and enforce compliance with product consensus standards as stated in "Technical Strategies."
- ❑ Key materials identified in the Environmental Programming Matrix, that are not covered in consensus standards, are to be selected based on the resources and criteria listed in Tools and References, or predicated on additional consultant research.

LEVEL 2

- ❑ For insulation and carpet pads (and any other potential CFC or HCFC source material), the products shall not use any halons, CFCs, or HCFCs as foaming agents or in other stages of the manufacturing process.
- ❑ Based on total materials cost, between 20-50% of the materials (excluding costs for mechanical and electrical systems, plumbing systems, labor, overhead fees etc.) shall contain at least 20% post-consumer recycled content OR a minimum of 40% pre-consumer recycled content. Document the materials and corresponding percentages accordingly.
- ❑ Also document that a minimum of 20% of the materials used in the project are composed of materials *manufactured* (not just distributed) within 300 miles of the building site, based on cost of materials. Again, calculations should exclude plumbing systems, mechanical and electrical systems, labor, overhead fees, etc.
- ❑ Document that 5-10% of the total materials cost has been directed towards salvaged or refurbished materials (total material costs excluding plumbing systems, mechanical and electrical systems, labor, overhead fees, etc.

Tools

The following tools can assist consultants in developing specification criteria for environmentally preferable materials:

- ➤ *Air Force Green Facilities Guide*, http://www.afcee.brooks.af.mil/green/facilitiesguide/erfguide.pdf
- ➤ *Green Specifications Research, Final Report* , US Department of State, Office of Foreign Buildings Operations, PB98-149776 Order #1030-612623. Prepared by Hellmuth, Obata + Kassabaum, P.C., Washington, DC. *Available from National Technical Information Service: http://tradecenter.ntis.gov/*
- ➤ *Forest Stewardship Council*, http://www.fscoax.org/ *The FSC promotes responsible forest management by evaluating and accrediting certifiers, encouraging the development of national and regional forest management standards, and strengthening national certification capacities through the development of certification initiatives worldwide.*
- ➤ *SmartWood*, http://www.smartwood.org *SmartWood is an independent certification operation that evaluates and certifies forestry operations that meet the international environmental standards of the Forest Stewardship Council. Forestry operations are certified based upon environmental, social, and sustainable forest management standards. SmartWood can also source certified wood products.*
- ➤ *Scientific Certification Systems*, http://www.scs1.com/index.html *An independent certification program used to verify environmental claims made by manufacturers of products and packaging materials. Wood products are evaluated and certified through SCS's Forest*

Conservation Program.

- *Green Seal,* http://www.greenseal.org/index.htm *A non-profit organization "dedicated to protecting the environment by promoting the manufacture and sale of environmentally responsible consumer products."*
- *EPA Comprehensive Procurement Guidelines (CPG)*, http://www.epa.gov/cpg *Defines recommended percentages of total recovered materials and post-consumer materials in building products.*
- *HOK Healthy & Sustainable Building Materials Database,* http://www.HOK.com/sustainabledesign *This web site contains recommendations for sustainable material selection and specification practices. Recommendations take into account environmental, life cycle, and sustainability issues.*

Deliverables

Pre-Preliminary.

- ❍ Environmental Programming Matrix. In the Environmental Programming Matrix, identify and define particularly sensitive spaces based on client agency preferences.

Design Development.

- ❍ Outline Specifications. Include a materials and products report on health and resource efficiency measures. Provide a rationale the each of the measures identified, along with specific materials proposed. Identify measures and materials in the outline specifications.

Construction Documents.

- ❍ Develop specification language for environmentally preferable materials and systems. Be sure to include:
  - Environmental criteria for specific material types
  - Methods of installation (as required)
  - Additional contract language that highlights and clarifies environmental goals and intent, as needed.

Construction Phase.

- ❍ Ensure submission of MSDSs and product certifications by contractors and subcontractors throughout construction phase. Ensure that all product substitutions meet environmental specification criteria.

End of Construction.

- ❍ Owner's Manual. The Owner's Manual is to include a compilation of product certifications, including VOC content, recycled content, MSDSs, and any other certifications or product information required in the specifications.

Regulatory Constraints

- **Proprietary Items.** Contract documents may not contain proprietary or sole source items. Some environmentally preferable products may be so new that there are only one or two manufacturers.
- **Materials and Equipment Approval (MEA).** All products used in New York City buildings must have a Materials and Equipment Approval (MEA) number issued by the Board of Standards and Approvals. Newer products may not have obtained an MEA number.

References

The following references contain life cycle assessment information, environmentally preferable product listings, and case study data on various building materials and systems.

The Environmental Resource Guide, The American Institute of Architects (AIA). John Wiley & Sons, Inc., 1 Wiley Drive, Somerset, NJ 08875. (800) 225-5945, The AIA Environmental Resource Guide provides detailed life cycle assessments of a number of construction materials. Additional material reports, including updates and revisions, are published on a biannual basis.

National Park Service Sustainable Design and Construction Database. A database of over 1,300 product listings from over 550 manufacturers. A brief review is provided for each product delineating environmental attributes and concerns. The database is free, and must be downloaded from the web site: http://www.nps.gov/dsc/dsgncnstr/

Sustainable Building Sourcebook. This site contains the entire contents of the *Sustainable Building Sourcebook* produced by the city of Austin, Texas as part of their Green Builder program. The *Sourcebook* provides concise, practical reviews of materials and pertinent life cycle issues, material attributes, and concerns. Lists of product manufacturers and trade organizations are also provided, along with numerous links to other green building web sites. http://www.greenbuilder.com/sourcebook

BEES (Building for Environmental and Economic Sustainability). Created by the National Institute for Standards and Technology (NIST), BEES software analyzes life cycle-based environmental and economic impacts for a limited group of building materials. This tool is currently under development, with version 1.0 currently available for evaluation. http://www.nist.gov/public_affairs/update/upd980427.htm

Resources for Environmental Design Index (REDI). A database of over 1,800 companies that sell green building products. The companies are organized in accordance with the 16-division MasterformatTM system, and can be searched using key words. Although product descriptions are not provided, environmental attributes are identified using keyed-in symbols. Some direct links to manufacturers' web sites are also included. http://www.oikos.com/redi/index.html

Environmental Building News (EBN), 28 Birge Street, Brattleboro, VT 05301. (802) 257-7300
A leading periodical reporting on environmentally preferable products and systems, EBN reviews various construction materials based on life cycle performance criteria. Articles are geared toward building professionals. EBN also publishes the EBN Products Catalog, which contains extensive product information, including manufacturers' literature. http://www.ebuild.com

The Green Building Resource Guide, John Hermannsson, AIA, The Taunton Press, 63 South Main Street, P.O. Box 5506, Newtown, CT 06470. (203) 426-8171, Extensive listings of environmentally preferable products and manufacturers. www.greenguide.com

Landmarks Preservation Commission (New York City-run salvage program) Architectural Salvage Warehouse, 337 Berry Street, Brooklyn, NY 11211. Appointments can be made by calling (212) 487-6782.

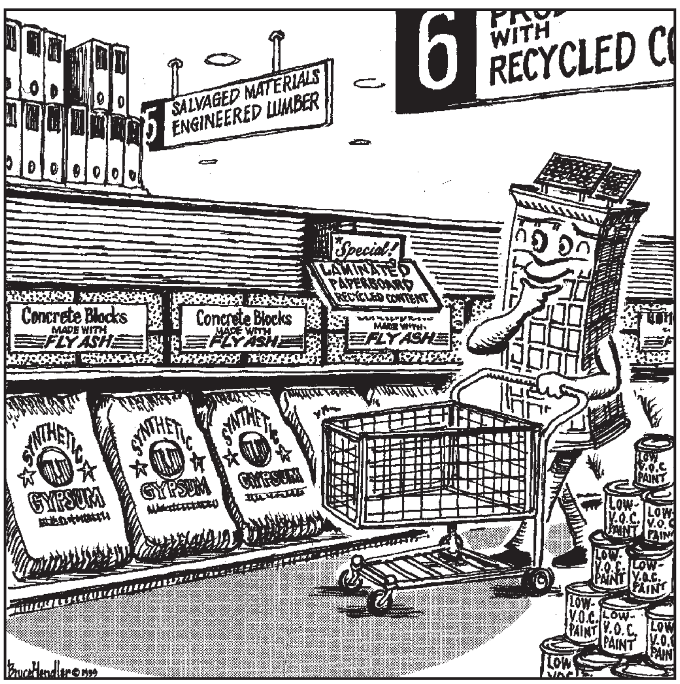


Illustration: Bruce Hendler

Water Management

Plumbing systems have evolved from being a simple means of distributing water and collecting wastes into increasingly sophisticated systems that must also address environmental concerns. The design of a plumbing system must incorporate not only traditional issues of sanitation, flow, and pressure, but also environmentally based preferences for recycling wastewater, use of non-utility water,[70] and different treatments for potable and non-potable water. New technologies, responses to water efficiency concerns, and community-based water quality goals pose numerous challenges for 21st Century plumbing design. These challenges are often exacerbated by stresses induced by rapid development. NYC has been blessed with one of the finest water supply systems available anywhere. High performance water management practices will help ensure the continued availability of this high quality resource.

70. "Non-utility" water refers to water not provided by the utility, such as rainwater and graywater.

Water Management

Minimize the Use of Domestic Water

Benefits ◀

$\$O_M$
Reduced use lowers municipal costs for water treatment.

$\$C_M$
Widespread conservation reduces demand and can avoid future waste water treatment facilities construction, along with associated capital costs.

Proper selection of plumbing fixtures, equipment, and fittings can minimize end use of domestic water while conserving water quality and availability.

Technical Strategies

❑ **Fixture and fitting selection.** Select plumbing fixtures and fittings that evince state-of-the-art capabilities in terms of water conservation. Seek improved performance by specifying low water usage water closets, urinals, showers, and lavatories–especially those that perform above the standards already mandated by federal, state and local laws. Consider the use of:

- Pressure-assist toilets
- Composting toilets
- Waterless urinals (in high use areas)
- Automatic shut-off controls on sinks, toilets, and urinals

❑ **Ozonation.** Consider ozonation in commercial laundering systems, condenser water systems, and other special uses to reduce water usage and secure other benefits.

Water Savings – Toilets and Faucets

New York's Marriot Marquis Hotel replaced 1,800 guest room toilets (operating at approximately five gallons per flush) with 1.6-gallon pressurized-tank toilets, resulting in an 18% reduction in total water use. In addition to typical residential water end uses, the hotel also has extensive restaurant, catering, and recreational facilities, as well as some laundry facilities. During 1994-1997, the New York City Department of Environmental Protection (DEP) sponsored the replacement of 1.33 million toilets citywide. Some showerheads were replaced and faucet aerators installed as part of the project. An impact evaluation of project results in multi-family buildings found an average reduction in water use of 29%, or 69 gallons per apartment per day.

Ozone Laundry

Ozone laundry systems use ozone (oxygen activated with an electrical charge) in lukewarm water to reduce the need for detergents, bleach, and hot water. Ozone is a short-lived, unstable gas that is created on site with an electrical generator, and immediately begins to convert back to oxygen. In the process, it oxidizes fatty oils and breaks the bond between dirt and clothing. Ozone laundry systems complement traditional laundry equipment in facilities handling large quantities of textiles, such as hospitals, nursing homes, and correctional institutions. Ozone is also an extremely effective biocide. Other benefits include hot water (energy) savings, reduced water and sewer costs, chemical cost reductions, improved sewage quality, and reduced textile degradation.

Water Quality

All projects must ensure optimal water quality at the tap – potable water that is both safe (non-toxic) and aesthetically pleasing in terms of taste, color, and odor.

▶ **Benefits**

$\$P_F$
Minimizes the chance of elevated lead blood levels in users.

G
Achieves savings in health care costs.

Technical Strategies

- ❑ **Standards**. Specify plumbing components that are certified meeting ANSI/NSF Standard 61 – *Drinking Water System Components – Health Effects.*
- ❑ **NSF certification.** Obtain proof of NSF certification[71] for each plumbing component. NSF testing data pertaining to a particular component should be issued.
- ❑ **Water sampling.** To ensure adequate water quality, upon completion of the plumbing system, flush the system and conduct water sampling at taps and service line(s) entering facility. At a minimum, test for lead, copper, pH, and turbidity. Water quality results should be within EPA maximum contaminant levels and action levels (EPA 40 Code of Federal Regulations Parts 141-149).
- ❑ **Filtration devices at point of entry and/or use.** To achieve the highest quality water for cooking and drinking, consider installation of filters at taps and/or at the service line(s) or house main.
- ❑ **Drinking water.** Use filtered tap water for drinking instead of bottled water, as this will avoid the additional cost and pollution resulting from bottling and distribution.

Clean Facility Water
A facility that employs water testing *prior to occupancy* and ongoing filtering can avoid loss of use and while ensuring that the occupants have access to high quality potable water upon occupancy and thereafter.

Water Reuse

To achieve overall water conservation goals, it is important to limit the use of potable water for non-potable purposes. On-site water reclamation and reuse should be encouraged and facilitated wherever possible.

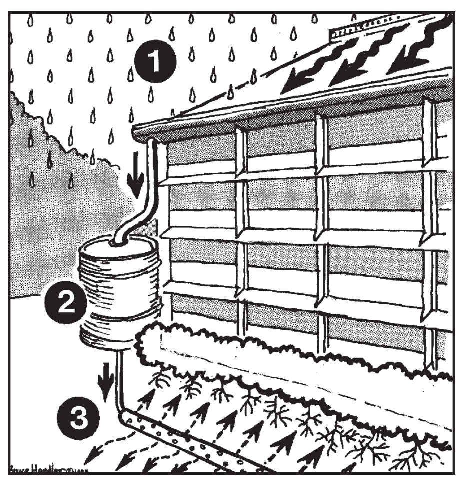
▶ **Benefits**

$\$O_M$
Reduces municipal costs for water treatment.

$\$C_M$
Diverting stormwater can reduce future capital costs for water treatment and delivery.

Technical Strategies

- ❑ **Rainwater use.** Collect and use rainwater for landscape irrigation, urban gardening, toilet/urinal flushing, roof cooling (for uninsulated roofs), and for other purposes as appropriate.
- ❑ **Green roofs.** Plant roof areas to reduce the discharge of stormwater and to reap the benefits of increased green space (recreation, bird habitat, roof shading, etc.).
- ❑ **Graywater use.** Collect and use graywater for water closets and urinal flushing, as well as for washdown of floor drains.
- ❑ **Excess groundwater.** Recover excess groundwater from sump pumps for use as a source of recycled water.
- ❑ **Steam condensate.** Collect and use utility district steam system condensate for toilet/urinal flushing, cooling tower make-up, and other non-potable uses (applies to Manhattan projects only).
- ❑ **'Vacuum-assist' systems.** Consider a 'vacuum-assist' system (in lieu of a standard system) for flushing of water closets and urinals.
- ❑ **Site retainage of rainwater.** Reduce rainwater runoff from the site, roofs, and building surfaces to minimize stress on NYC combined sewer system and to divert and reduce water pollution.



Water Harvesting
In this illustration, rainwater ❶ is collected in a cistern ❷, for controlled release over time ❸.
Illustration: Bruce Hendler

71. NSF International is an independent, not-for-profit organization dedicated to public health, safety, and protection of the environment. The organization develops standards, provides superior third-party conformity assessment services, and strives to represent the interests of all stakeholders.

Graywater

The Headquarters Park office complex in Princeton, New Jersey is composed of four buildings totaling 366,500 square feet. The original estimate of wastewater flow was 27,450 gallons per day (gpd). The designers considered a wastewater recycling system that would effectively avoid the costs of advanced treatment (including denitrification) which is required in facilities with flows in excess of 2,000 gpd. The wastewater recycling system, which provides on site treatment and recycling of both 'gray' and 'black' water, reduced flows to 1,600 gpd, or approximately 6% of the original estimate. This system has been in service since 1987 and was the first such system approved by code authorities and installed in New Jersey. The water recycling system cost $250,000 less than the originally contemplated treatment system, lowers operating costs, and provides $15,000 per year in water bill savings (based on 1987 rates).

Building Integration

Site Design and Planning. There is a relationship between site harvesting of and storage of rainwater and minimizing the facility's domestic water use by utilizing this retained water for non-potable uses.

Building Energy Use. Reduced hot water usage lowers building energy consumption.

PERFORMANCE GOALS

Water Management

LEVEL 1

- ❑ Use plumbing components that are certified to meet ANSI/NSF 61 *(see Tools).*
- ❑ Where appropriate, use harvested or retained water for seasonal irrigation of all plant materials and/or non-potable water uses within the building.

LEVEL 2

- ❑ The facility should maintain water quality that meets EPA's maximum contaminant level goals (MCLGs) *(see Tools).*
- ❑ Integrate zero water use fixtures and graywater systems as appropriate.

Tools

- ➤ ANSI/NSF Standard 61 – *Drinking Water System Components-Health Effects.*www.nsf.org
- ➤ EPA Code of Federal Regulations, Parts 141-149.
- ➤ New York State Department of Health publishes a listing of certified testing labs.

Deliverables

Preliminary Design. Testing data, to include:

- ❍ ANSI/ASME performance test results for plumbing fixtures.
- ❍ NSF certification and testing data for plumbing components.
- ❍ Quantified potential savings from water management strategies.

Construction.

- ❍ Lab results of water quality testing at the point(s) of incoming service.

Post-Construction.

- ❍ Lab results of water quality testing at taps.

Regulatory Constraints

➠ The NYC Building Code does not specifically address approved materials and methods for the use of graywater. All innovative systems (such as those strategies suggested above) may raise issues of concern with local code authorities. Effective implementation requires working closely with code officials to obtain a variance for using non-potable water as flushwater for water closets and urinals, as well as for other graywater uses. In addition, regulatory approvals are required for the use of vacuum-assist water closet systems.

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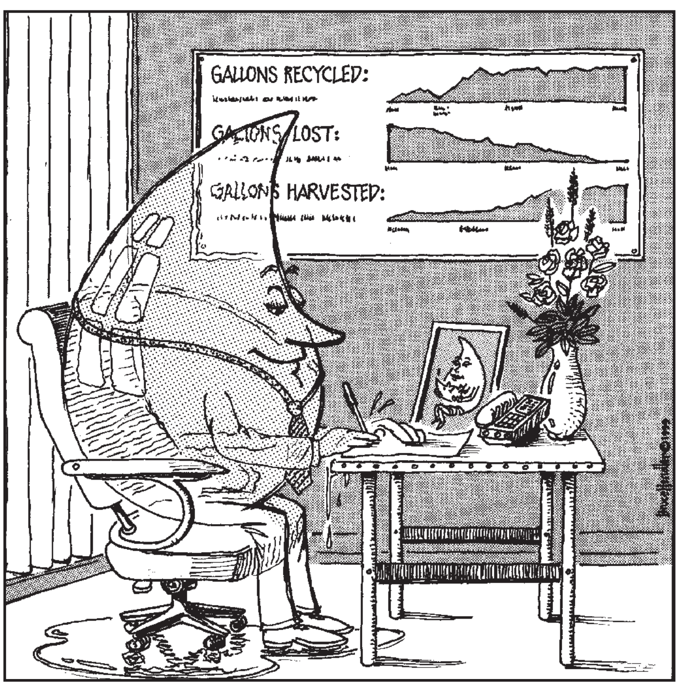


Illustration: Bruce Hendler

Construction Administration

Building construction and renovation activities alter the urban environment, generating noise, waste, and air pollution that can stress the building's occupants and neighbors. High performance construction practices can help reduce adverse effects during construction while improving the building's long-term environmental performance. In particular, construction and demolition (C&D) waste[72] has become an increasing environmental and municipal burden, equaling up to 30% of the municipal solid waste stream. At present, the majority of this waste is disposed of by private haulers engaged by demolition subcontractors and landfilled out of state, at increasing cost to New York City taxpayers. The strategies that follow can reduce the amount of C&D waste generated at the start, and encourage better waste management methods through salvage and recycling.

72. Construction and demolition debris is the waste stream generated by new construction, by renovation, and by the demolition of existing buildings.

Construction Administration

Benefits

E_S
Protection of the site's ecological resources.

G
Improved facility and community relations through reduced environmental degradation.

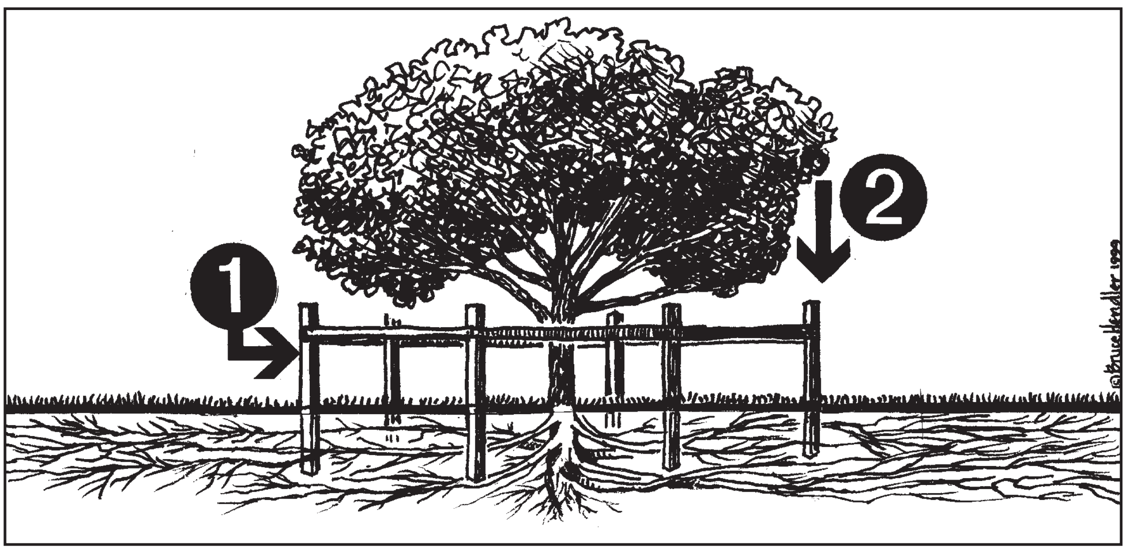
Environmental and Community Considerations

Renovation and new construction should be performed with the least possible disruption to both the community and the environment. Conscientious construction administration can minimize harm to the site and surrounding area, including soil, water resources, and air. Construction of the project should foster the perception of high performance buildings as good neighbors.

Technical Strategies

❑ **Site Protection Plan.** Develop contract documents to require the provision of a Site Protection Plan by the contractors. The Plan's basic elements include:

- A protection plan for vegetation/trees.
- A 'tree rescue' plan for those trees and plantings that must be removed (a park, community garden, nursery, or some other entity may want them).
- A site access plan, including a designated staging or 'lay down' area designed to minimize damage to the environment. Indicate storage areas for salvaged materials, and access and collection areas for recyclable materials, including day-to-day construction waste (packaging, bottles, etc.). Designate site-sensitive areas where staging, stockpiling, and soil compaction are prohibited.
- Waste water runoff and erosion control measures.
- Measures to salvage existing clean topsoil on site for reuse.
- Plans to mitigate dust, smoke, odors, etc.
- Noise control measures, including schedules for particularly disruptive, high decibel operations, and procedures for compliance with the Department of Environmental Protection's noise regulations.



Tree Protection During Construction
To help ensure that trees are not lost during construction, consider the following:
A. during construction, the largest single killer of tree roots - and thus of trees - is soil compaction by heavy machinery;
B. the roots of most species of large, woody trees grow primarily horizontally;
C. these roots are predominantly located in the top 12" (30cm) of soil, and do not normally extend to depths greater than 3' to 7' (1 to 2 meters), yet extend outward to an average diameter of 1 to 2 times the height of that tree.
As such, tree guards should be erected to protect trees during construction, but since it would be impractical in most cases to establish a complete protection zone, tree guards ❶ should reach at least to the "drip line" ❷ of the tree's crown. This action will minimize root death and the corresponding dieback of the tree's crown.
Illustration: Bruce Hendler

Trees and Construction

New York City's sidewalk trees have a 36% mortality rate.[73] This means that 1 out of 3 trees planted at curbside are dead within five years. There are several reasons for tree loss in urban areas, including water saturation, damage from autos (the wounds where cars hit trees allow fungus to enter, which kills the tree), salt, tree stakes, and to a lesser extent, vandalism and pollution. Construction is also a leading cause of tree mortality. While causal data is lacking in New York City, a study in Boston concluded that more street trees were killed by construction or the after-effects of construction than any other cause.[74]

Health and Safety

Construction workers and building occupants need protection from pollutants produced during construction, such as volatile organic compounds (VOCs), particulates, dust and other airborne contaminants and odors. These same construction contaminants must also be prevented from accumulating in building HVAC systems and in absorbent building materials, such as carpet and furnishings.

▶ **Benefits**

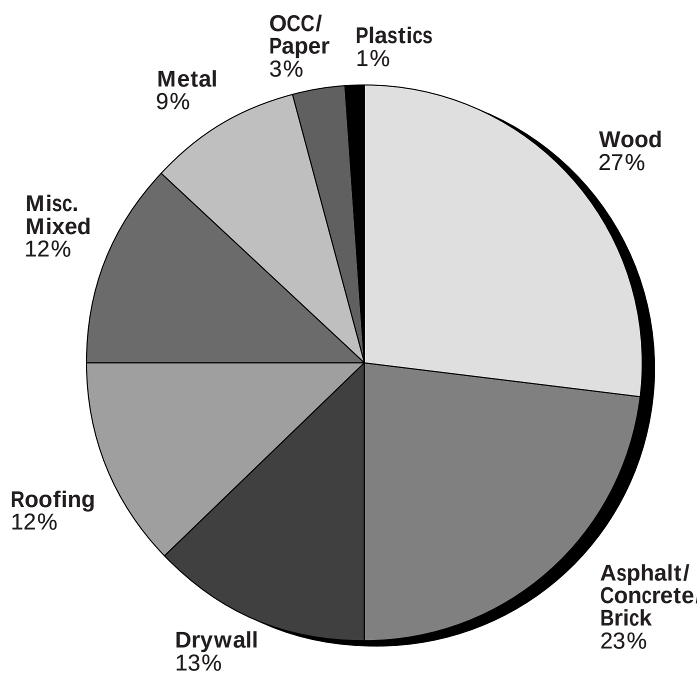
C_F$
Avoids remediation costs associated with post-occupancy indoor air quality problems.

P_F$
Improves worker and occupant comfort and safety during construction.

Technical Strategies

❑ **Health and Safety Plan.** Develop contract documents requiring the contractor to produce a Health and Safety Plan.[75] The Plan should complement the building's air quality design and provide for:

- Adequate separation and protection of occupied areas from construction areas.
- Protection of ducts and airways from accumulating dust, moisture, particulates, VOCs and microbials resulting from construction/demolition activities.
- Increased ventilation/exhaust air at the construction site.
- Scheduling of construction procedures to minimize exposure of absorbent building materials to VOC emissions. For example, complete 'wet' construction procedures such as painting and sealing *before* storing or installing 'dry,' absorbent materials such as carpets and ceiling tiles. These porous components act as a 'sink,' retaining contaminants and releasing them over time.
- Posting of material safety data sheets in high traffic, accessible locations.
- A flush-out period, beginning as soon as systems are operable and before or during the furniture, fittings, and equipment installation phase. The process involves flushing the building with 100% outside air for a period of not less than 20 days.
- Appropriate steps to control vermin *(see Appendix H)*.
- Prevention of pest infestation once the building or renovated portion is occupied using integrated pest management (IPM) *(see Appendix I)*.



Construction and Demolition Waste
(average composition, as disposed)

Source: US Environmental Protection Agency, www.epa.gov

73. Environmental Action Coalition assessment, 1998.
74. Foster, Ruth S. and Blaine, Joan. "Urban Tree Survival: Trees in the Sidewalk," *Journal of Arboriculture* 4(1): January 1978.
75. Reference *Indoor Air Quality Guidelines for Occupied Buildings Under Construction*, Sheet Metal Air Conditioning and Contractors' National Association. The plan should also reference Department of Buildings Tenant Safety Plan (Directive of January 6, 1984) and Site Safety Plan (NYC Building Code, Article 26-01).

Construction and Demolition Waste Management

Benefits ◀

$\$O_M$
Diverted C&D waste preserves landfill space.

$\$D_S$
Encourages producer reclamation and waste-handling markets for recycled products.

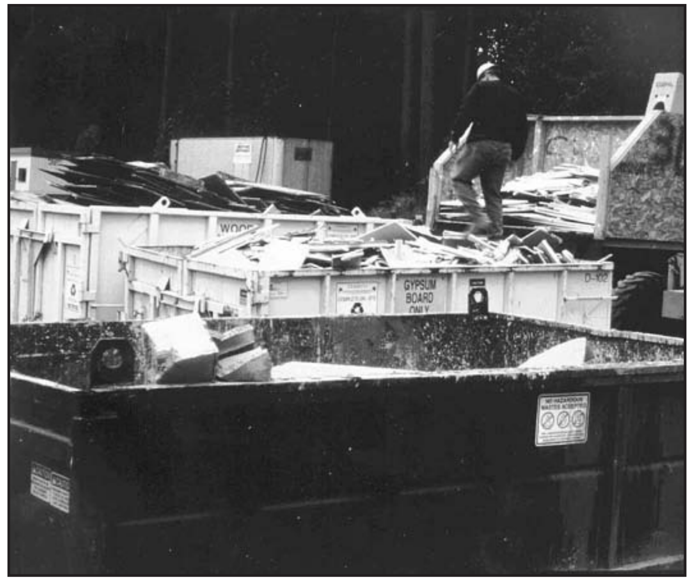
E_S
Materials salvaging and reuse preserves natural resources and reduces soil, water, and air pollution.

Construction and demolition (C&D) waste management techniques divert materials from the waste stream, thus preserving valuable resources and landfill space. C&D waste typically includes building demolition and scrap materials, components such as doors or lighting fixtures, packaging materials, hazardous materials, and miscellaneous construction waste such as bottles, cans, or paper.

Technical Strategies

❑ **Waste Management Plan.** Stipulate a requirement in the contract documents requiring a Waste Management Plan by the contractors. The plan will include the measures listed below. Where referenced, existing guidelines or standards should be used to define the scope of a specific measure.

- ❍ **Salvaged Materials.**
  - List materials to be salvaged for reuse in the project in the contract documents.
  - Identify local haulers for salvaged materials and products that will not be reused in the project. List additional materials that are economically feasible for salvaging in the project.
- ❍ **Recycling.**
  - Identify licensed haulers of recyclables and document costs for recycling and frequency of pick-ups. Confirm with haulers what materials will and will not be accepted. List those materials that are economically feasible for recycling in the project.
  - Identify manufacturers and reclaimers who recover construction/demolition scrap of their products for recycling. List materials that are economically feasible for reclamation and any special handling requirements for each material. Examples include carpets, ceiling tiles, and gypsum wallboard.
  - List procedures to be taken to comply with New York City recycling law. Recyclable materials include bulk metals, corrugated cardboard, bottles, and cans.
- ❍ **Packaging.**
  - Identify manufacturers who reclaim their packaging for reuse or recycling. Identify manufacturer and distributor options for reduced packaging, where available.
- ❍ **Hazardous Materials.**
  - Develop procedures for separating hazardous waste by-products of construction (examples include paints, solvents, oils and lubricants) and for disposing of these wastes according to appropriate federal, state, or local regulations.
- ❍ **Other Waste Prevention Measures.** The following are applicable to any project:
  - Educate workers on waste prevention goals and the proper handling and storage of materials.
  - Where applicable, re-use salvaged material at the site.
  - Coordinate ordering and delivery of materials among all contractors and suppliers to ensure that the correct amount of each material is delivered and stored at the optimum time and place. This can help prevent material loss, theft, and damage.



C&D Waste Sorting
Materials routinely separated on Sellen Construction's jobsites include woodwaste, gypsum wallboard and concrete (shown here) as well as cardboard, metals, and office recyclables.
Courtesy of Sellen Construction Co., Inc.

The Rose Garden, Portland, Oregon

The Rose Garden, a new arena for the Oregon Trail Blazers basketball team, was completed in 1995. The project involved demolition of a car wash manufacturing facility and a parking lot, as well as a portion of the Portland Coliseum exhibition hall. Ninety-two percent of the waste generated was reused or recycled, for a savings of about $200,000. A C&D consulting firm identified materials for reuse and recycling, and worked closely with subcontractors to ensure proper implementation. Due to space limitations, 24-hour hauling services were enlisted to transport source-separated materials. Almost 4,000 tons of materials were salvaged for reuse in this project.

Building Integration

City Process. Community Boards should be made aware of the Construction Site Protection Plan.

Site Design and Planning. Coordinate site protection issues with site inventory and analysis actions, including identification of sensitive environmental areas, wildlife habitats, etc.

Indoor Environment. Thoughtful staging of construction procedures can prevent or reduce problems with indoor air quality when the building is occupied.

Material and Product Selection. Salvaged materials at the site can be reused.

Commissioning. In keeping with the Health and Safety Plan, protection and cleaning of the HVAC system is an integral aspect of a successful commissioning process.

PERFORMANCE GOALS

Construction Administration

LEVEL 1

- ❑ Implement Construction Site Protection Plan.
- ❑ Implement Health and Safety Plan for construction.
- ❑ Implement Waste Management Plan.

LEVEL 2

- ❑ Prepare and implement a comprehensive C&D Waste Management Plan consistent with Triangle J Waste Spec: *Waste Specifications for Construction Waste Reduction, Reuse and Recycling.* Client agency and consultants to set waste recovery goals based on material types and/or total targeted percentage of material to be recovered.

Tools

- ➤ Triangle J Council of Governments, WasteSpec: *Model Specifications for Construction Waste Reduction, Reuse, and Recycling*, North Carolina, May 1995. www.state.nc.us/TJCOG/cdwaste.htm
- ➤ Proposed revisions to the current ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality – Section 7.1, Construction Phase. American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc. (ASHRAE), 1989.
- ➤ *IAQ Guidelines for Occupied Buildings Under Construction*, Sheet Metal and Air Conditioning Contractors' National Association (SMACNA), Chantilly, VA, November, 1995.

Deliverables

Pre-Preliminary Phase.
As part of the High Performance Plan, the consultant should, in a brief narrative, outline the scope of construction issues to be included in the final design drawings and specifications. The description of scope shall address the following:

- ❍ Site Protection Plan as outlined in "Technical Strategies."
- ❍ Construction Health and Safety Plan which provides for the protection of worker and building occupant health relative to indoor air quality and pest control.
- ❍ Waste Management Plan with procedures for salvaging selected materials, recycling of construction and demolition material, and legally disposing of hazardous materials.

Final Design Phase.

- ❍ Specification language in the Special Conditions or Specific Requirements section of the Specifications (as prepared by the consultant) shall define the following deliverables to be provided by the construction contractor(s):
  - Site Protection Plan, as outlined under "Technical Strategies."
  - Construction Health and Safety Plan, which provides for the protection of worker and building occupant health relative to indoor air quality and pest control.
  - Waste Management Plan, with procedures for salvaging selected materials, recycling of construction and demolition material, and legally disposing of hazardous materials.

Construction Phase.

- ❍ The City will monitor implementation of the Site Protection Plan, Construction Health and Safety Plan, and Waste Management Plan. Construction contractors are to document the types and quantities of materials salvaged or recycled for the project, and submit salvage/recycling records to the consultant and client agency.

Regulatory Constraints

- ➠ **Wicks' Law.** Special coordination efforts must be undertaken when implementing high performance construction administration strategies in a multi-contractor environment. The implementation responsibilities of each of the requisite four prime contractors should be clearly delineated.

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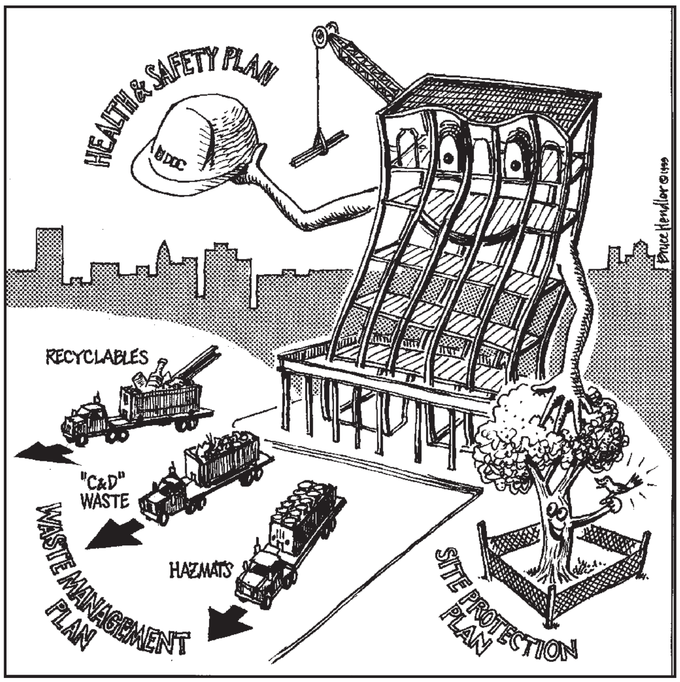


Illustration: Bruce Hendler

Commissioning

The commissioning process assures the building owner that the equipment, systems, and controls providing light, heat, cooling, and ventilation are effectively working together in conformance with design intent. Commissioning determines whether the systems need to be adjusted to improve efficiency, indoor air quality, and acoustic performances. The commissioning process encompasses–but also surpasses–the normal testing, adjusting, and balancing (TAB) activities commonly performed in inspections. *Commissioning also involves comprehensive functional testing to determine how well mechanical and electrical systems work together.* Because so many building systems are now integrated, a deficiency in one component can result in substandard operation and performance among other components.

In general practice, a commissioning agent assists the construction team in substantively reducing and eliminating defects before the building is turned over to its occupants. Commissioning may also occur based on a partial system upgrade.

Commissioning

Fully Integrated Operating Systems

"Commissioning is a systematic process, beginning in the design phase, lasting at least one year after construction, and including the preparation of operating staff, of ensuring, through documented verification, that all building systems perform interactively according to the documented design intent and the owner's operational needs."

Participants in the first National Conference on Building Commissioning

Benefits ◀

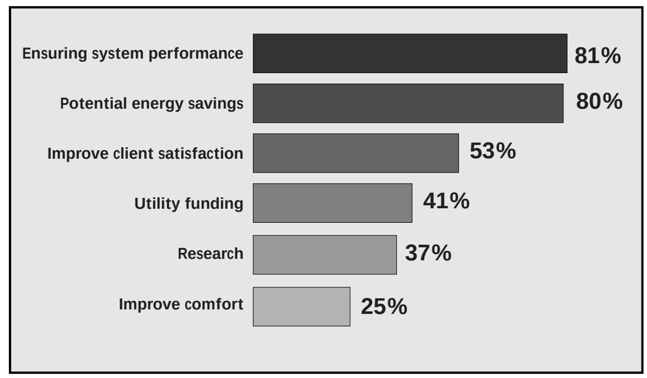
0_F
Proper and efficient operation of mechanical and electrical systems minimizes operational costs, extends equipment life, minimizes downtime due to component failures, and reduces contractor callbacks.

P_F
Optimized performance of systems supports thermal comfort and indoor air quality, which are essential to the health and performance of occupants.

Commissioning activities transform the various building systems into an integrated whole. During all tests and performance protocols, a dedicated commissioning agent oversees the building team to ensure that the systems have been well-designed, appropriately installed, and functionally tested, and that the staff are trained to operate and maintain the facility in conformance with design intent.

Benefits of Commissioning
According to a survey of owners involved in 175 projects (with a median facility size of 66,000 s.f.) that have been commissioned since 1994, the primary reasons to commission buildings is to ensure system performance and to reduce energy costs.
Source: Portland Energy Conservation, Inc.

Why Owners Commission Their Buildings



Technical Strategies

The project team should determine the need for commissioning procedures, including the phases during which commissioning is needed. The team should then identify the individual(s) responsible for administering the activities described below. *(For a detailed explanation of commissioning activities refer to ASHRAE Guideline 1-1996.)*

- ❑ **Programming and Budget Phase.**
  - ❍ Determine the budget for appropriate levels of commissioning activities. Levels of commissioning can range from a single-source testing and verification contract to full-scale involvement of a dedicated commissioning team, including design integration and review, construction process review, interactive systems testing, and operations and maintenance staff training.
  - ❍ Identify the systems that require commissioning *(see Systems or Components to be Included in the Commissioning Process, below.)*
  - ❍ Identify the person or persons responsible for developing and overseeing project commissioning (independent contractor, construction manager, or City representative) and determine the responsibilities of individual team members.
- ❑ **Design Phase.**
  - ❍ Review all milestone design documents for compliance with initial design intent.
  - ❍ Develop the Commissioning Plan.
  - ❍ Develop the commissioning specifications to be produced by consultant or commissioning agent.
  - ❍ Review contract documents to assure complete coordination among the various trades, paying careful attention to construction sequences, materials storage, and site access.
- ❑ **Construction Phase.**
  - ❍ Finalize details of the commissioning procedures.
  - ❍ Review shop drawings and equipment submittals.
  - ❍ Conduct periodic commissioning team meetings.
  - ❍ Observe construction, installation, start-up, operation, testing, and balancing.

- ❑ **Acceptance Phase.**
  - ❍ Verify conformance of building system performance with design intent.
  - ❍ Identify deficiencies discovered during the commissioning process and make corrective recommendations.
  - ❍ Assemble completed as-built records, including instruction manuals prepared by equipment manufacturers, fabricators, or installers for inclusion in the Owner's Manual.
  - ❍ Verify the accuracy and completeness of final testing, adjusting, and balancing reports.
  - ❍ Conduct operations and maintenance staff training.
- ❑ **Post-Acceptance Commissioning.**
  - ❍ Administer continuing adjustment, optimization, and modification of systems to meet specified operating requirements.

Commissioning Existing Buildings

For a building renovation or infrastructure upgrade, commissioning should be performed on the affected systems or parts of systems in a comprehensive manner.

Technical Strategies

- ❑ **Existing systems evaluation.** Evaluate existing systems not previously commissioned, and adjust systems as required to achieve optimal performance for present and future anticipated performance levels.
- ❑ **Building tune-ups.** Consider extending the benefits of commissioning to other (or all) building systems to extend the life of these systems and to improve overall building performance.

Systems or Components to be Included in Commissioning Process:

- ❑ **Building Envelope.**
  - Exterior wall system, including fenestration.
  - Roofing membrane.
- ❑ **HVAC.**
  - Air-handling, distribution, and ventilation systems.
  - Hydronic distribution systems.
  - Heating plant and associated systems.
  - Cooling plant and associated systems.
  - Building automation systems and controls; direct digital controls/energy management control systems.
- ❑ **Electrical.**
  - Fire detection and alarm systems.
  - Fire protection/suppression systems.
  - Electrical main switchgear and power systems.
  - Motor control centers.
  - Lighting systems and controls.
  - Stand-by power systems, uninterrupted power supply systems.
  - Variable frequency drives.
- ❑ **Plumbing Systems.**
  - Domestic hot water systems.
  - Water pressure booster systems.
  - Gas pressure booster systems.
- ❑ **Other Specialty Equipment and Systems.**

DDC Pilot Program
DDC is proceeding with a pilot commissioning program for its high performance building for the Administration for Children's Services intake and training center. DDC will use its consultant team, together with a commissioning agent retained through the construction manager, to commission the building upon completion of construction and prior to occupancy.

Building Integration

Operations and Maintenance. The bridge between commissioning and operations and maintenance is formed by training and sustained through development of a comprehensive Owner's Manual, which should be updated on a regular basis.

PERFORMANCE GOALS: NEW CONSTRUCTION AND RENOVATION

Commissioning

❑ Commission the building in accordance with ASHRAE Guideline 1-1996.

Tools

➤ ASHRAE Guideline 1-1996 (with sample contract language and specifications).
➤ *Building Commissioning Guidelines*, 2nd Edition, Bonneville Power Administration, prepared by Portland Energy Conservation, Inc., November 1992.
➤ General Services Administration (GSA) *Model Commissioning Plan and Guide Specifications*, U.S. General Services Administration Public Building Service and U.S. Department of Energy
➤ *International Performance Measurement and Verification Protocol*, U.S. Department of Energy, December, 1997.

Deliverables

Pre-Preliminary Phase. Develop the Commissioning Opportunities Scope segment of the High Performance Plan. This entails the identification and description of the scope of commissioning activities to be performed before and after construction completion. The scope description should include the following tasks:

❍ Produce a commissioning outline plan, describing the systems scheduled for commissioning, nature of testing to be performed, attendance, and required documentation.
❍ Produce a commissioning test plan, including schedule development and implementation for pre-functional testing and functional testing.
❍ Issue a final commissioning report.
❍ Develop a training program for building operators.

Design Development Phase.

❍ Review and comment on design development documents.

Construction Documents.

❍ Consultant or commissioning agent to develop commissioning specifications for incorporation into the contract documents.

Construction.

❍ Commissioning agent to develop detailed commissioning test plan identifying tests to be performed, schedules, and attendance required for pre-functional testing and functional testing.
❍ Commissioning agent to produce progress reports delineating test results and making recommendations for rectifying deficiencies.

Commissioning

- ❍ Commissioning agent to submit Final Evaluation Report, which summarizes the results of functional testing and makes recommendations for rectifying deficiencies.

Occupancy.

- ❍ Produce a training videotape that records all sessions covered in the training of operations and maintenance personnel.
- ❍ Issue a final report compiling all results, findings, and documentation produced in support of the commissioning process.

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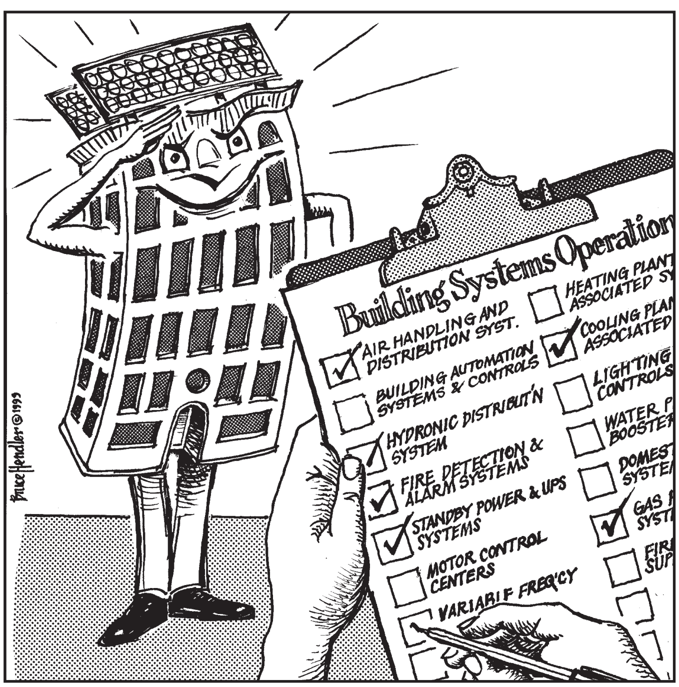

Illustration: Bruce Hendler

Operations and Maintenance

Adequate planning for the efficient operation and maintenance of a building and its systems is a critical component of high performance design and construction. Design strategies that address operations and maintenance (O&M) issues can result in reduced custodial costs and lower energy consumption. Exposure to physical and chemical hazards, toxins, odors, and potential asthma 'triggers' can be reduced or eliminated. Efficient operation and maintenance also enhances the indoor environment and may contribute positively to user/occupant well-being and productivity. To achieve successful operations and maintenance, it is important to ensure that planned systems and strategies are consistent with the resources available to the client agency.

Operations and Maintenance

Operating and Maintaining Building Systems

Benefits ◀

$\$0_F$

Operational savings are achieved through efficient management of systems and extended life of equipment and materials, reduced damage and repairs to equipment and systems, and energy savings that accrue based on proper systems maintenance.

Operating and maintenance practices ensure that all building systems[76] function to the fullest extent of their designed efficiency and meet specified levels of energy and indoor air quality performance. Scheduled maintenance and cleaning will help to yield ongoing energy savings for the building while promoting occupant health and comfort.

Technical Strategies

- ❑ **Staff participation.** Actively engage client agency's O&M staff from the point of substantial construction completion through commissioning and building occupancy.
- ❑ **Simplification.** Simplify building systems design to promote ease of maintenance. For example, employ lighting design solutions that minimize the number of different types of lamps, so that they may be easily changed and maintained.
- ❑ **Access to systems.** Design for adequate access to building systems. Equipment manufacturers and operations staff should be consulted on access points and needed clearances early in the design process.
- ❑ **Maintaining envelope performance.** Ensure weathertightness through a building envelope maintenance program that minimizes thermal bridging. This can be achieved through activities such as immediate replacement of damaged glazing, timely repointing of masonry, resealing of roof cracks, and maintaining proper weatherstripping and vapor barriers.
- ❑ **Window cleaning.** Schedule regular window cleaning to maximize the benefits of daylighting, particularly where windows are close to sources of air-borne dust, fumes, or gases that reduce the transmission of light.
- ❑ **Relamping.** Perform relamping using the most energy efficient lamps (and ballasts, if applicable). In a facility that has many older lamps, group relamping can be very cost effective. If group relamping proves impractical, replace lamps as they burn out with more efficient lamps, rather than simply replacing the old ones with lamps of the same type.
- ❑ **Training.** To assure optimum performance, provide O&M staff with adequate training in systems operations and maintenance.
- ❑ **Operations and Maintenance Manual.** Refer to the Operations and Maintenance Manual (written in accordance with ASHRAE Guideline 4-1993, "Preparation of Operating and Maintenance Documentation for Building Systems") provided to the client agency's O&M staff.
- ❑ **Safety and Health Coordinator.** An agency-appointed Safety and Health Coordinator[77] should develop procedures for reporting and documenting IAQ complaints and subsequent actions taken.[78]
- ❑ **Morning purge.** When the energy penalty is not too severe or where heat recovery ventilators are in place, run a system purge during morning start-up and/or during maintenance and cleaning. This should be performed from time to time, mainly during spring and fall when energy penalties are slight. Avoid start-up control sequences where dampers are closed; maintain proper pressures at all times.
- ❑ **Ongoing system maintenance.** Perform adequate system maintenance, including periodic cleaning, oiling, and minor repairs, as well as scheduled major system overhaul.
- ❑ **Energy performance review.** Review energy consumption on a quarterly basis. Consideration should be given to hours of operation, peak usage patterns, fixture efficiency, and maintenance practices. Report irregularities to the NYC Office of Energy Conservation and agency budget analysts.

76. For the purposes of the *Guidelines*, 'building systems' include all mechanical, electrical, plumbing, building envelope, fire detection and suppression, telecommunications, and food service systems.
77. Mayor's Executive Order No. 38 Relating to the Citywide Occupational Safety and Health Program: General Provisions (supersedes Personnel Policy and Procedure No. 740-77b), October 1, 1997.
78. See: *Building Air Quality Action Plan*, EPA 402-K-98-001, United States Environmental Protection Agency, National Institute of Occupational Safety and Health, June 1998. Document may be downloaded at www.epa.gov/iedweb600/base/baqact.html

Centralized Building Management System
New York Public Libraries has instituted a centralized building management system (BMS), which enables monitoring and control of all branches' HVAC systems from the Main Branch at 42nd Street. The BMS calls up each library on a computer and checks status remotely. Because maintenance problems (such as dirty filters) are checked electronically, many systems can be repaired or maintained before a more serious breakdown occurs.

Healthy and Efficient Custodial Operations

Reduced human exposure to physical and chemical hazards and odors associated with cleaning products and pesticides can be achieved through custodial operations that employ appropriate methods and low-toxicity or non-toxic cleaning products.

Technical Strategies

❑ **Preventative Strategies.**

- Select textured paving (rather than smooth surfaces) for outside approaches, so that soils are scraped off shoes prior to building entry. Plantings bordering walkways should not be of the type that drop flowers or berries that can be tracked into the building.
- Minimize introduction of dirt with appropriately sized, recessed metal grating within vestibules. Consider installing additional 'walk-off' mats in entryways to further prevent dirt from entering the building.
- Design kitchen areas and restrooms for ease of maintenance. Specifically, restroom stall partitions should be suspended from the ceiling or extended from walls to expedite floor cleaning and eliminate soil build-up on legs and supports. Sinks should be recessed into counter tops or molded as a single unit with a front lip that keeps water from spilling onto the floor.[79]
- Design janitor's closets or central storage facilities with adequate space for cleaning product storage and the mixing of concentrated cleaning solutions. Provide separate outside venting operated under negative pressure.

❑ **Ongoing Maintenance Strategies.**

- Select healthy and environmentally preferable cleaning products *(see Appendix J).* Obtain material safety data sheets (MSDSs) and post in prominent, accessible locations.
- Consider the use of portion control devices such as mechanical dispensers, which help ensure safe mixing of cleaning solutions, save packaging, and reduce chemical consumption.
- Coordinate housekeeping and custodial operations with building ventilation schedules to ensure that adequate ventilation is provided, both during and after these activities.
- Since carpets tend to act as 'sinks' for dirt and dust, a vacuum with high-efficiency vacuum bags or high efficiency particle air (HEPA) filters should be used. When shampooing carpets, avoid overwetting and allow sufficient time for thorough drying. Water-damaged carpets can harbor mold and bacteria.
- Develop an Integrated Pest Management Plan *(see Appendix I).* This is especially important in facilities where children are housed or spend significant amounts of time.[80]
- Ensure that custodial staff are adequately trained and educated in the use of cleaning products and procedures. Foster a sense of pride, and provide performance incentives for custodial staff.

▶ **Benefits**

$\$O_F$
Operational savings (labor and materials) from efficient cleaning protocols and reduced use of chemical products.

$\$P_F$
The potential exists for improved worker/ occupant productivity, as well as potential reductions in absenteeism.

E_S
Negative impacts on the environment are reduced or eliminated by using low-toxicity or non-toxic cleaning products; this also helps develop markets for environ-mentally-friendly products and practices.

79. Ashkin, Stephen P. *Green & Clean: The Designer's Impact on Housekeeping and Maintenance*, Rochester Midland Corporation, presented at The 21st Century Outlook Conference, sponsored by American Institute of Architects, US Green Building Council, and US Department of Energy, November 6-9, 1997, Miami, Florida.
80. According to the American Lung Association, asthma is the leading serious chronic illness in children, and the estimated annual cost of treating asthma in those under 18 years of age is $1.9 billion. Numerous scientific studies have shown a strong link between asthmatic attacks and the presence of cockroaches.

- ❍ Institute procedures to prevent occasional or chronic water damage. Where damage has occurred, ensure that maintenance staff takes immediate action to repair the water source; remove and replace any damaged porous materials. Immediately eliminate standing water and condensate.
- ❍ Follow the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) *IAQ Guidelines for Occupied Buildings Under Construction* in planning for construction activities where material removal, painting, sanding, and other disruptive activities are anticipated.
- ❍ Ensure that custodial staff is adequately trained in the management and handling of hazardous materials, particularly lead and asbestos.
  - To promote asbestos awareness, see *Managing Asbestos in Place: A Building Owner's Guide to Operations and Maintenance Programs for Asbestos-Containing Materials*, US EPA, Pesticides and Toxic Substances (TS-799), 20T-2003, July 1990.
  - For lead awareness, training should include:
    - – Lead physical properties and characteristics
    - – Health effects and medical surveillance requirements
    - – Federal regulations
    - – State and health department regulations
    - – Lead-based paint identification techniques
    - – Worker protection equipment

Results of 'Green Housekeeping' Program at Brooklyn Public Library

Reduction of Toxins

Over 16 hazardous substances have been eliminated from BPL's cleaning operations.[82]

Reduction of Cleaning Product Usage

Facility staff estimates a reduction of approximately 50% in the amount of cleaning product used. This is primarily the result of using a proportioning chemical dispenser, which pre-mixes cleaners and disinfectants for accurate dilution.

Packaging Waste Reduction

The need for 55-gallon storage drums has been eliminated. In addition to being bulky and wasteful, these drums were difficult and dangerous to handle.

Improved Efficiency

The proportioning dispenser has been shown to save time because the need for mixing of products and walking back and forth for water has been eliminated. In addition, BPL staff believe that this initiative has boosted the morale of the custodial staff, and as a result, productivity has increased.

Brooklyn Public Library Green Team

Photo: Harry Yarwood, BPL

Public Education and Formation of the 'Green Team'

Comprised of a representative cross-section of departments as well as custodial staff, the Green Team has given library staff the opportunity to participate in positive change. In addition to overseeing the green housekeeping program, the Green Team has improved the library's purchasing and discard procedures. The Green Team also has educated the entire BPL system (approximately 1,400 people) on these important environmental initiatives.

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81. The Brooklyn Public Library (BPL) and Rochester Midland Corporation, together with DDC's Office of Sustainable Design and Construction, initiated a 'green housekeeping' program at BPL's central branch, Grand Army Plaza. The program aimed to improve the quality of the indoor environment by reducing toxins in cleaning products and increasing the efficiency of cleaning operations. After an initial trial period, which included establishing a baseline, staff training, installation of a proportioning product dispenser, and testing the program on one floor, the program was expanded to the entire library.
82. These include butoxyethanol, diacetone alcohol, dipropylene glycol, petroleum distillates, ethanolamine, ethyl ether, isobutane, isopropanol, methyl ether, naptha, nonyl phenolethoxylate.

Waste Prevention and Recycling

Reducing, reusing, and recycling solid, liquid, and food waste from day-to-day building operations and activities are critical high performance operating strategies, in that they effectively promote ongoing resource conservation. Purchasing decisions can also contribute to waste prevention (e.g., specifying mechanically-controlled roll towels instead of disposable folded towels; avoiding products with excessive or unnecessary packaging).

Technical Strategies

- ❑ **Education.** Educate client agency (users/occupants) on recycling and waste reduction measures. Publicize and reward successful employee efforts.
- ❑ **Waste prevention compliance.** Follow the Mayoral Directive on Waste Prevention and Efficient Materials Management Policies of 1996, which requires agencies to institute various waste prevention practices, such as double-sided copying and use of e-mail rather than paper for office communications.[83]
- ❑ **Recycling areas.** Provide dedicated areas for recycling bins, recycling chutes, and other accommodations to promote ease of waste management. Ensure that there is adequate storage space for–and access for removal of–recyclables.

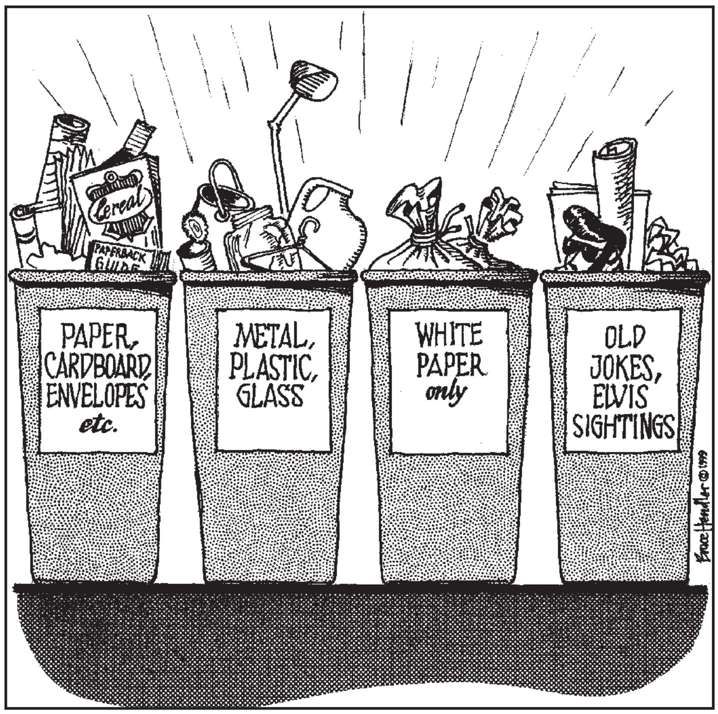

Illustration: Bruce Hendler

▶ **Benefits**

$\$O_M$
Municipal operational savings are achieved by diverting waste from landfills.

E_S
Environmental benefits accrue based on reduced material waste and consumption; conservation of natural resources.

Operations and Maintenance

83. For a copy of the Directive, contact the Mayor's Office of Operations at 212-788-1400.

❑ **Department of Sanitation requirements.** Comply with current Department of Sanitation requirements for recycling.[84]
❑ **Composting.** Consider composting if there is substantial food or yard waste.[85]
❑ **Water management training.** Provide maintenance staff with any necessary training to support rainwater/graywater management.

Composting Facility at Rikers Island
Photo: Joyce Lee

Building Integration

Site Design and Planning. Building site design must incorporate facilities and space for recycling. This includes space for collection and storage, as well as access for collection vehicles. Communicate with the client agency on plans for recycling and/or composting.

Site Design and Planning. Adhere to sustainable landscape practices as described in Site Design and Planning.

Indoor Environment. Properly cleaned and maintained HVAC systems support healthful indoor air quality.

Material and Product Selection. Select materials and products for ease of maintenance; e.g., materials that do not require unusual or potentially toxic cleaners, or combinations of cleaners in the same space.

Commissioning. Commissioning will inform and enhance the effectiveness of the building's operations and maintenance.

84. For most current recycling rules, client agencies should contact the Sanitation Action Center at (212) 219-8090.
85. For guidance on composting strategies, client agencies can contact the Sanitation Action Center, (212) 219-8090.

PERFORMANCE GOALS (FOR CLIENT AGENCIES)

LEVEL 1

- ❑ Maintain building systems to level of designed efficiency, according to equipment's life expectancy.
- ❑ Complete the Operations and Maintenance Manual as described in ASHRAE Guidelines 4-1993, *Preparation of Operating and Maintenance Documentation for Building Systems.* Ensure that the manual establishes criteria for evaluating the building's O&M program and commits the maintenance staff to basic standards of performance, such as prompt response to mechanical failure, ongoing maintenance, and attention to planned functions that protect the capital investment. Also seek to minimize downtime and expedite failure response time.
- ❑ Commit to HVAC system inspections as follows: (1) semi-annual inspection of HVAC system operation by designated and trained IAQ manager, including at minimum, intake points, filters, heat exchange units and coils, fans, main ducts, equipment rooms, damper linkages, condensate collection points, humidifiers and ceiling tiles in ceiling plenum spaces; (2) annual inspection to verify that dampers, valves, fans, VAV devices, and other active components respond to controls in accordance with design intent.
- ❑ Commit to establishing preventive maintenance procedures and performing these activities based on recommended scheduling as established in the O&M manual, so as not to defer scheduled and unscheduled maintenance.
- ❑ Follow SMACNA's IAQ *Guidelines for Occupied Buildings Under Construction* in planning for construction activities where material removal, painting, sanding, and other disruptive activities are anticipated.
- ❑ Institute a policy of 'lights out' in rooms left unoccupied for more than 15 minutes.
- ❑ Comply with current DOS recycling rules for city agencies and institutions.
- ❑ Cleaning products shall comply with the environmental and packaging requirements of the Green Seal Standard for Household Cleaners, GS-08, First Edition, November 2, 1993, Numbers 2 (Product Specific Environmental Requirements) and 3 (Packaging Requirements). www.greenseal.org/standard/h-cleanr.htm
- ❑ Examine feasibility of a green housekeeping program, including use of a proportioning dispenser and low-toxicity or non-toxic cleaning products.

LEVEL 2

- ❑ Formation of a 'Green Team' similar to that established by Brooklyn Public Library's main branch *(See Example on page 126).*
- ❑ Commit to documenting waste and strive to recycle 75% of total recyclable material. Note that total recyclable materials for a given agency may decrease once waste prevention measures are implemented.
- ❑ Where facilities exist, separate organic waste for composting.
- ❑ Commit to documenting the facility's overall annual building energy use and energy costs so as to establish a benchmark performance level. The benchmark energy use level shall be compared to energy use predictions established by the building design team, and/or shall be at or below the energy use (kbtu/sf/yr or equivalent $/sf/yr) standards developed in the EPA Energy Star Buildings program.
- ❑ As appropriate, institute energy efficient measures such as replacing failed standard electric motors with high efficiency motors; replacing incandescent lamps with compact fluorescent lamps and ballasts; calibrating equipment and controls to meet actual load conditions.

Tools

- ➤ Mayoral Directive on Waste Prevention and Efficient Materials Management Policies of 1996.
- ➤ United States Environmental Protection Agency, *Integrated Pest Management for Schools: A How-to Manual,* EPA 909-B-97-001, March, 1997.
- ➤ US Environmental Protection Agency, *Indoor Air Quality: Tools for Schools Action Kit,* Office of Radiation and Indoor Air, Indoor Environments Division (6607J), EPA 402-K-95-001, 1995. Available from http://www.epa.gov/iaq/schools/tools4s2.html. Additionally, two videos are available free of charge, "IAQ Tools for Schools–Taking Action" and "Ventilation Basics" available from IAQ Info Clearinghouse, (800) 438-4318.
- ➤ United States Environmental Protection Agency, *Managing Asbestos in Place: A Building Owner's Guide to Operations and Maintenance Programs for Asbestos-Containing Materials*, US EPA, Pesticides and Toxic Substances (TS-799), 20T-2003, July 1990.
- ➤ EPA Cleaning Products Pilot Project: http://www.epa.gov/opptintr/epp/cleaners/select/
- ➤ Green Seal Web Site: http://www.greenseal.org See: Green Seal, Inc. Standard for Household Cleaners (GS 08), First Edition, November 2, 1993 (While these standards are geared toward residential cleaners, they provide product-specific environmental requirements).

Deliverables

Pre-Preliminary Phase. High Performance Plan: Operational Waste Analysis.

❍ Identify and describe the scope of operations and maintenance issues to be implemented in the project, including the following:

- Maintenance implications of design alternatives and features.
- Waste prevention and recycling during building operations.
- Development of cleaning and maintenance schedules and protocols for systems and finishes.
- Identification of low-toxicity or non-toxic housekeeping materials.
- Space and access requirements to support recycling.

Design Development Phase.

❍ Recommend waste prevention and recycling measures.

Construction Documents.

❍ Perform a design review of materials and details from the standpoint of cleaning protocols and costs.

Post Occupancy.

❍ Development of low toxicity maintenance and cleaning protocols for the full spectrum of installed materials. Incorporate these protocols into the Owner's Manual.

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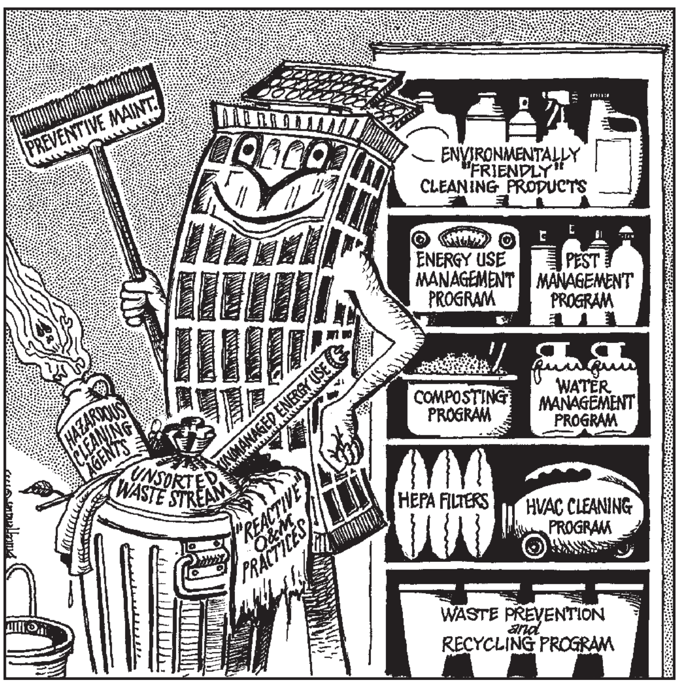

Illustration: Bruce Hendler

Part Four:
End Pages

End Pages

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'Environmentally Responsible' Building Guidelines Project

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GLOSSARY

Acceptable indoor air quality: Air in an occupied space toward which a substantial majority of occupants express no dissatisfaction and in which there are not likely to be known contaminants at concentrations leading to exposures that pose a significant health risk (ASHRAE 62-1989 draft revision).

Acid rain: Acid rain is formed when sulfur dioxide and nitrogen oxides – pollutants resulting primarily from burning coal, oil, and other fossil fuels – mix with water vapor in the atmosphere to create acidic compounds. Acid rain impacts aquatic ecosystems, high altitude forests, creates haze, and contributes to the deterioration of buildings and historical monuments.

"Air-lock" entrances: A passive device that acts as a buffer to prevent conditioned air from escaping a building. Usually a set of double doors or a revolving door.

Albedo: The ratio of reflected light to the total amount falling on a surface. A high albedo indicates high reflectance properties.

Biodiversity: The tendency in ecosystems, when undisturbed, to have a large number and wide range of species of animals, plants, fungi, and microorganisms. Human population pressure and resource consumption tend to reduce biodiversity.

Bioswale: Strategically placed earthen depression that capture stormwater and filter it using native wetland plants.

Brise-soleil: An exterior architectural element designed to control the penetration of direct sunlight into a building.

Brownfields: Abandoned, idled, or under-used industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination.

Buffer: A 'buffer' is a strip of heavily vegetated land that absorbs and filters runoff water.

Building commissioning: A systematic process beginning in the design phase, lasting at least one year after construction, and including the preparation of operating staff of ensuring, through documented verification, that all building systems perform interactively according to the documented design intent and the owner's operational needs.

Building related illness: The term "building related illness" (BRI) is used when symptoms of diagnosable illness are identified and can be attributed directly to airborne building contaminants. *See also "sick building syndrome."*

Carbon dioxide (CO_2): A naturally occurring greenhouse gas in the atmosphere, concentrations of which have increased (from 280 parts per million in preindustrial times to over 350 parts per million today) as a result of humans' burning of coal, oil, natural gas and organic matter (e.g., wood and crop wastes).

Chlorofluorocarbons (CFCs): A family of chemicals used in refrigeration, air conditioning, packaging, insulation, or as solvents and aerosol propellants. Because CFCs are not destroyed in the lower atmosphere they drift into the upper atmosphere where their chlorine components destroy the earth's protective ozone layer.

Clerestory: Clerestories have many of the attributes of skylights except that they occur in the vertical rather than the horizontal plane.

Climate change: A regional change in temperature and weather patterns. Current science indicates a discernible link between climate change over the last century and human activity, specifically the burning of fossil fuels.

Composting: A process whereby organic wastes, including food wastes, paper, and yard wastes, decompose naturally, resulting in a product rich in minerals and ideal for gardening and farming as a soil conditioner, mulch, resurfacing material, or landfill cover.

Daylighting: The method of illuminated building interiors with natural light.

Demand control ventilation: Ventilation provided in response to actual number of occupants and occupant activity.

Design charrette: The charrette process is a focused workshop(s) which takes place in the early phase of the design process. All project team members meet together to exchange ideas, encouraging generation of integrated design solutions.

Dust spot efficiency: The dust spot efficiency test is a semi-quantitative measure of a filter's collection efficiency for fine particles – those associated with smudging of the interior surfaces of buildings. Upstream and downstream paper target filters collect particles and the opacity (light transmission) is measured.

Embodied energy: Embodied energy accounts for all energy expended for production and transportation plus inherent energy at a specific point in the life cycle of a product.

Energy modeling: A computer model that analyzes the building's energy-related features in order to project energy consumption of a given design.

Environmentally preferable: Products or services that have a lesser or reduced effect on human health and the environment when compared with competing products or services that serve the same purpose. This comparison may consider raw materials acquisition, production, manufacturing, packaging, distribution, reuse, operation, maintenance, or disposal of the product or service.

Fossil fuel: A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.

Fuel cell: A technology that uses an electrochemical process to convert energy into electrical power. Often powered by natural gas, fuel cell power is cleaner than grid-connected power sources. In addition, hot water is produced as a by-product that can be utilized as a thermal resource for the building.

Geothermal heat exchange technology: In winter, geothermal heat exchange technology utilizes heat from subsurface water to heat buildings; in summer, this technology extracts heat from the building into subsurface water for cooling.

Global warming: Increase in the average temperature of the earth's surface.
(See 'greenhouse effect').

Graywater: Wastewater that does not contain sewage or fecal contamination and can be reused for irrigation after simple filtration.

Greenhouse effect: The process that raises the temperature of air in the lower atmosphere due to heat trapped by greenhouse gases, such as carbon dioxide, methane, nitrous oxide, chlorofluorocarbons, and tropospheric (ground level) ozone.

Heat recovery systems (sensible and latent): Building mechanical systems that capture waste heat from another system and use it to replace heat that would otherwise come from a primary energy source.

Hydrochlorofluorocarbon (HCFC): HCFCs are generally less detrimental to depletion of stratospheric ozone than related chlorofluorocarbons. HCFCs are generally used to replace CFCs where mandates require CFCs to be eliminated. A total ban on all CFCs and HCFCs is scheduled effective 2030.

Integrated pest management: A coordinated approach to pest control that is intended to prevent unacceptable levels of pests by the most cost-effective means with the least possible hazard to building occupants, workers, and the environment.

Ion generators: Ionizers or ion generators act by charging the particles in a room so that they are attracted to walls, floors, tabletops, draperies, occupants, etc. Abrasion can result in these particles being re-suspended into the air. In some cases, these devices contain a collector to attract the charged particles back to the unit. While ion generators may remove small particles (e.g., those in tobacco smoke) from the indoor air, they do not remove gases or odors, and may be relatively ineffective in removing large particles such as pollen and dust allergens.

K-Rated transformer: A transformer used to supply power to non-linear loads such as computers. It is a specially designed transformer with an oversized neutral to accommodate the high neutral current caused by the harmonics generated by the equipment served.

Life cycle assessment: The comprehensive examination of a product's environmental and economic aspects and potential impacts throughout its lifetime, including raw material extraction, transportation, manufacturing, use and disposal.

Life cycle cost: The amortized annual cost of a product, including capital costs, installation costs, operating costs, maintenance costs, and disposal costs discounted over the lifetime of a product.

Light pollution: Light pollution – excess brightness in the sky resulting from direct and indirect lighting above urban areas – has had a negative impact on the urban ecology, disrupting biological cycles in plants and animals. It has also been hypothesized that human health requires a certain amount of exposure to darkness. The amount of energy wasted in lighting the sky or outdoor and indoor spaces, which do not need it, has been estimated conservatively to reach approximately $2 billion per year in the US.

Light shelf: A light shelf is a horizontally-placed light reflector.

Low-e windows: "Low-E" (low-emissivity) windows reflect heat, not light, and therefore keep spaces warmer in winter and cooler in summer.

Low pressure drop high efficiency air filters: Extended surface pleated air filters that allow greater air filtration without a significant increase in fan horsepower requirements.

Material safety data sheet (MSDS): Forms that contain brief information regarding chemical and physical hazards, health effects, proper handling, storage, and personal protection appropriate for use of a particular chemical in an occupational environment.

Monolithic building systems: A characteristic of architectural building systems that are comprised of a few larger elements with few if any joints between them.

Nitrogen oxide (NO_x): A product of combustion from transportation and stationary sources such as power plants. NO_x is a major contributor to acid rain and to ground level ozone (the primary component of smog).

Operations & Maintenance: *Operations* refers to how equipment or systems are run, e.g., when a system should be turned on, temperature ranges, set points for boiler pressures and temperatures, thermostat set points, etc. *Maintenance* refers to servicing or repair of equipment and systems. "Preventive maintenance" performed on a periodic or schedule basis to ensure optimum life and performance is designed to prevent breakdown and unanticipated loss of production or performance. "Corrective" or "unscheduled" maintenance refers to repairs on a system to bring it back "on-line." "Predictive" maintenance is performed on equipment monitored for signs of wear or degradation, e.g., through thermography, oil analysis, vibration analysis, maintenance history evaluation.

Ozone: 1. *Stratospheric ozone:* In the stratosphere (the atmosphere layer beginning 7 to 10 miles above the earth), ozone is a form of oxygen found naturally which provides a protective layer shielding the earth from ultraviolet radiation's harmful effects on humans and the environment.
2. *Ground level ozone.* Ozone produced near the earth's surface through complex chemical reactions of nitrogen oxides, volatile organic compounds, and sunlight. Ground level ozone is the primary component of smog and is harmful to humans and the environment.

Photovoltaic panels (PVs): Photovoltaic devices use semiconductor material to directly convert sunlight into electricity. Power is produced when sunlight strikes the semiconductor material and creates an electric current.

Post-consumer recycled content: Post-consumer material is a material or finished product that has served its intended use and has been discarded for disposal or recovery, having completed its life as a consumer item.

Pre-consumer recycled content: Pre-consumer material is material diverted from the waste stream following an industrial process, excluding reutilization of materials such as rework, regrind or scrap generated in a process and capable of being reclaimed within the same process. Synonyms include post-industrial and secondary material.

R-value: A measure of the thermal resistance of material.

Radiant cooling: A cooling system in which temperatures of room surfaces are adjusted to maintain comfort by absorbing the heat radiated from occupants.

Recycling: The series of activities, including collection, separation, and processing, by which products or other materials are recovered from the solid waste stream for use in the form of raw materials in the manufacture of new products other than fuel for producing heat or power by combustion.

Renewable energy: Energy resources such as wind power or solar energy that can keep producing indefinitely without being depleted.

Sick Building Syndrome: The term "sick building syndrome" (SBS) is used to describe situations in which building occupants experience acute health and comfort effects that appear to be linked to time spent in a building, but no specific illness or cause can be identified. The complaints may be localized in a particular room or zone, or may be widespread throughout the building. Also See: *"building related illness."*

"Sink": Gases and vapors often adsorb, and particles deposit, on surfaces such as carpet, drywall, etc. These surfaces are known as "sinks" – contaminants can be re-emitted from the sinks at a later time.

Stack - effect: The phenomenon in a building or building component caused by wind pressure and temperature differentials which results in air being drawn through some components of a building and out others creating a continuous pattern of air flow.

Superheating: Process of adding heat to the refrigerant beyond its saturation point.

Sulfur dioxide (SO_2): An air pollutant formed primarily by coal and oil burning power plants. SO_2 combines with other pollutants to form acid rain.

Thermal bridge: A highly conductive element such as a metal channel in the building envelope that penetrates or bypasses the less conductive element such as insulation, and acts as a thermal short circuit through the insulation system.

Thermal buffer: A space or other element that reduces the heating and cooling load on another space located between the space and the exterior.

Thermal flywheel: A building element such as a solid masonry wall that collects heat during one period and releases it during another in a repetitive pattern.

Urban heat island effect: The additional heating of the air over a city as the result of the replacement of vegetated surfaces with those composed of asphalt, concrete, rooftops and other man-made materials. These materials store much of the sun's energy, producing a dome of elevated air temperatures up to 10^{o}F greater over a city compared to air temperatures over adjacent rural areas. Light colored rooftops and lighter colored pavement can help to dissipate heat by reflecting sunlight, and tree planting can further help modify the city's temperature through shading and evapotranspiration.

Variable air volume (VAV): Use of varying air flow to control the condition of air, in contrast to the use of constant flow (often) with varying temperature.

Veiling reflections: Veiling reflections can be created by light sources in specific locations when a task contains primarily specular (shiny) surfaces, such as a video display terminal or glossy magazine; a luminous veil is apparent.

Volatile organic compounds: Volatile organic compounds (VOCs) are chemicals that contain carbon molecules and are volatile enough to evaporate from material surfaces into indoor air at normal room temperatures (referred to as off-gassing). Examples of building materials that may contain VOCs include, but are not limited to: solvents, paints adhesives, carpeting and particleboard. Signs and symptoms of VOC exposure may include eye and upper respiratory irritation, nasal congestion, headache and dizziness.

ACRONYMS

ACEEE	American Council for an Energy Efficient Economy
ACS	New York City Administration for Children's Services
AIA	American Institute of Architects
AIMS	Asset Information Management Survey
ANSI	American National Standards Institute
ASEAM	A Simplified Energy Analysis Method
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BLAST	Building Loads and System Thermodynamics
BMS	Building Management System
BPL	Brooklyn Public Library
BTU	British thermal unit
C&D	Construction and demolition (waste)
CFCs	Chlorofluorocarbons
CFD	Computational fluid dynamics
CO_2	Carbon dioxide
CPG	Comprehensive Procurement Guidelines
DCAS	New York City Department of Citywide Administrative Services
DCV	Demand Control Ventilation
DDC	New York City Department of Design and Construction
DOE	United States Department of Energy
DOE-2.1E	United States Department of Energy computer modeling
DOS	New York City Department of Sanitation
DOT	New York City Department of Transportation
DPR	New York Department of Parks and Recreation
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
EPACT	Energy Policy Act of 1992
FGD	Flue-gas desulfurization (gypsum)
FRESA	Federal Renewable Energy Screening Assistant
FSC	Forest Stewardship Council
GSA	United States General Services Administration
HAP v4.0	Hourly Analysis Program
HCFCs	Hydrochlorofluorocarbons
HVAC	Heating, ventilating, air conditioning
IAQ	Indoor air quality

IESNA	Illuminating Engineering Society of North America
IPM	Integrated pest management
LEED	Leadership in Energy and Environmental Design
MCLGs	Maximum Contaminant Level Goals
MEA	Materials and Equipment Approval
MSDS	Material Safety Data Sheet
MSW	Municipal solid waste
NC	Noise Criteria
NIST	National Institute for Standards and Technology
NO_X	Nitrogen oxides
NRDC	Natural Resources Defense Council
NYPA	New York Power Authority
NYSERDA	New York State Energy and Research Development Authority
O&M	Operations and maintenance
OEC	New York City Office of Energy Conservation
OMB	New York City Office of Management and Budget
OSDC	DDC Office of Sustainable Design and Construction
PV	Photovoltaic
RFP	Request for Proposals
RMANs	Recycled Materials Advisory Notices
SCS	Scientific Certification Systems
SMACNA	Sheet Metal and Air Conditioning Contractors' National Association
SO_2	Sulfur dioxide
SO_x	Sulfur oxides
SR	Specific Requirements
STC	Sound Transmission Class
TAB	Testing, adjusting and balancing
TRNSYS	Transient system simulation program
ULURP	Uniform Land Use Review Process
UPS	Uninterrupted power supply
USGBC	United States Green Building Council
VAV	Variable air volume (systems)
VOCs	Volatile organic compounds

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